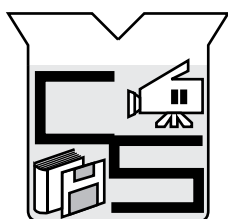
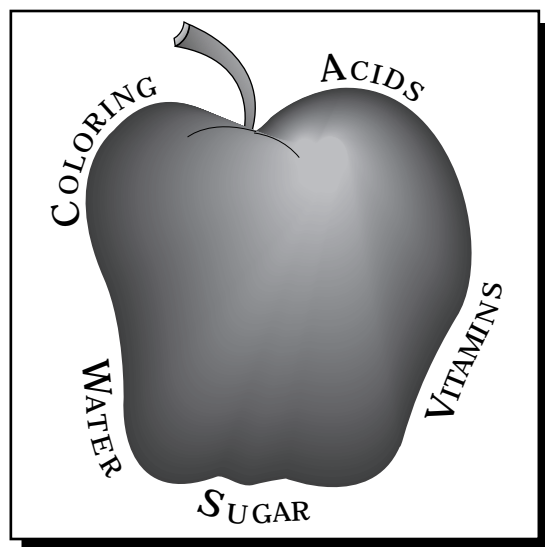


# A SourceBook Module

Version 1.0 1993

*Funded in part under  
National Science Foundation  
Grant No. TPE 88-50632*

*ChemSource Project Principal Investigator:  
Mary Virginia Orna, OSU  
Department of Chemistry  
College of New Rochelle  
New Rochelle, NY 10805  
Phone: (914) 654-5302  
FAX: (914) 654-5387*

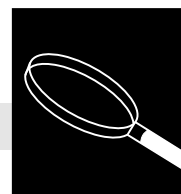


ChemSource

*Instructional Resources for Preservice and  
Inservice Chemistry Teachers*

FOOD AND CHEMISTRY

# Topic Overview



## CONTENT IN A NUTSHELL

“What in the world *isn't* chemistry?” We often read or view statements leading the average person to believe that all chemicals are dangerous, that they should be avoided, and that “natural” substances are preferable to “chemicals.” But every natural thing is made of chemicals: the food we eat, the air we breathe, the clothes we wear, and even our own bodies.

In this module, students will study some of the foods they eat and investigate how to use and buy the products they consume. Although no new concepts are introduced, many fundamental chemical concepts such as oxidation-reduction, acids and bases, and biochemistry are reinforced by the subject matter in this chapter. Students will see that chemicals are part of their daily nutrition and learn that “natural” products such as milk yield to analysis just like chemicals from the stockroom.

## PLACE IN THE CURRICULUM

This module may be used at all levels of study. Some parts assume knowledge of fundamental concepts.

## CENTRAL CONCEPTS

1. Not all chemical substances are bad for human consumption. Foods are essential for our existence.
2. Certain compounds and elements are essential for a balanced diet.
3. The body has certain nutritional requirements, and the foods we eat affect our health.
4. Labels on foods and other products are important in helping consumers understand the nature of the ingredients and additives used.

## RELATED CONCEPTS

1. Oxidation-reduction
2. Solution properties
3. Basic organic chemistry
4. Nutritional needs
5. Protein chemistry

## RELATED SKILLS

1. Good observational skills
2. Quantitative techniques

## PERFORMANCE OBJECTIVES

After completing their study of food and chemistry, students should be able to:

1. know that foods are made of chemical substances.
2. describe some laboratory activities that can be done with everyday substances.
3. read and analyze some labels and determine the best buy in certain substances.
4. classify food additives (*e.g.*, acids, bases, sweeteners, preservatives) according to their properties.



# Concept/Skills Development

## *Activity 1: Analysis of NaCl in Snack Food*

### Introduction

Table salt (sodium chloride, NaCl) is an important component of the human diet. Since too much salt may cause health problems such as high blood pressure or kidney and heart disease, “low salt” or “low sodium” foods have become popular and are readily available. Additionally, the Federal Government requires all food to be labeled with its nutritional components, including sodium. In this laboratory activity, you will determine the actual amount of NaCl in Fritos<sup>®</sup> snack food.

Prior to the laboratory, your instructor soaked a known amount of Fritos<sup>®</sup> in distilled water to dissolve the salt. You will be given the information about the mass of Fritos<sup>®</sup> used and the total volume of the solution obtained. You are to assume that all the salt from the Fritos<sup>®</sup> dissolved.

### Purpose

To determine the mass of NaCl in a package of Fritos<sup>®</sup> using the Mohr chloride titration method.

### Safety

1. Wear protective goggles throughout the laboratory activity.
2. Silver nitrate ( $\text{AgNO}_3$ ) solutions stain skin and clothes; wash off immediately to prevent stains.
3. Potassium chromate ( $\text{K}_2\text{CrO}_4$ ) is toxic if taken internally, and may irritate the skin. Wash off immediately to prevent skin irritation.

### Procedure

1. Obtain from your instructor information about the mass of Fritos<sup>®</sup> used and the total volume of the solution. Record these values in your Data Table.
2. Fill the buret above the 50-mL mark with the  $\text{AgNO}_3$  solution. Open the stopcock to fill the buret tip and remove the bubbles. Record the Initial Reading for the Blank analysis in the Data Table. (The buret level does NOT have to be at 0.0 mL.)
3. Blank titration: Using a pipette, transfer 10.0 mL distilled or deionized water into a 125-mL Erlenmeyer flask and add 20 drops chromate indicator. Titrate with the  $\text{AgNO}_3$  solution to a pinkish-orange end point. Record the mL of  $\text{AgNO}_3$  used. Repeat 2-3 times and average the values. A blank value of 0.2-0.3 mL is normal.
4. Sample titration: Using a pipet, transfer 10.0 mL Fritos<sup>®</sup> filtrate into a 125-mL flask and add 20 drops chromate indicator. Titrate with  $\text{AgNO}_3$  until a pinkish-orange end point is reached. It should look almost like orange juice. Keep this titration flask for comparison with the next trial. Repeat Step 4 two additional times and record in the Data Table. If your results are not consistent ( $\pm 0.5$  mL), you should do additional sample titrations.
5. When you have completed the titrations, clean your buret as directed by your instructor. Remember that  $\text{AgNO}_3$  stains the skin. Titration solutions should be disposed of as directed by your instructor.
6. Thoroughly wash your hands before leaving the laboratory.

## LABORATORY ACTIVITY: STUDENT VERSION





## Data Analysis and Concept Development

1. Average the blank titration values.
2. Average the sample titration values. Subtract the average blank value from the average sample value.
3. Using the ratio,  $\frac{0.825 \text{ mg NaCl}}{1 \text{ mL AgNO}_3}$ , calculate mg NaCl per gram of sample.
4. Calculate the mg NaCl in the entire package of Fritos®.
5. Calculate mg Na in the entire package.
6. How do your experimental values compare with the stated value on the label? Can you explain any discrepancy?

### Data Table

	Trial 1	Trial 2	Trial 3
<b>Blank Titration</b>			
Final:	_____	_____	_____
Initial:	_____	_____	_____
mL AgNO <sub>3</sub> Used:	_____	_____	_____
Average mL AgNO <sub>3</sub> used for the blank:		_____ mL	
<b>Sample Titration</b>			
Final:	_____	_____	_____
Initial:	_____	_____	_____
mL AgNO <sub>3</sub> Used:	_____	_____	_____
Average mL AgNO <sub>3</sub> used for the sample:		_____ mL	
Average mL AgNO <sub>3</sub> for Cl <sup>-</sup> titration (sample-blank):		_____ mL	
Mass of Fritos® used:			_____ g
Total volume of filtrate:			_____ mL

## Implications and Applications

1. Find the recommended level of sodium intake in the daily diet.
2. Examine a package of your favorite salty snack and find the mass of sodium listed. Calculate the mass of NaCl, and teaspoons of NaCl, assuming that one teaspoon of NaCl has a mass of approximately 6 g.
3. If someone has a family history of high blood pressure, stroke, kidney, or heart disease, what dietary changes would a physician recommend to that person with regard to salt intake?

## Activity 1: Analysis of Sodium Chloride in Snack Food

### Major Chemical Concept

Students will use the Mohr Chloride Titration method (see *Pre-Laboratory Discussion* Items 3 and 4) to determine the amount of sodium chloride in a snack food such as Fritos®.

### Level

This activity is appropriate for all levels of chemistry classes.

### Expected Student Background

**Skills:** Using a buret, pipet, and unit analysis calculations. **Concepts** Solubility, averaging values of several trials in an analysis, using a “blank” in chemical analysis.

### Time

40-50 min, if snack filtrate is prepared ahead of time.

### Safety

Read the *Safety Considerations* in the *Student Version*.

### Materials (For 24 students working in pairs)

#### Nonconsumables

- 48 Erlenmeyer flasks, 125-mL
- 12 Burets, 50-mL
- 12 Pipets, 10-mL
- 12 Ringstands and buret clamps

#### Consumables (see *Advance Preparation*)

- 0.0141 M Silver nitrate,  $\text{AgNO}_3$ , 600 mL
- 12 dropping bottles 5% Potassium chromate,  $\text{K}_2\text{CrO}_4$
- Snack filtrate, 480 mL

### Advance Preparation

1. Preparing the snack filtrate: Weigh out 20.0 g of crushed Fritos®; soak 24 hr in 600 mL distilled water; filter through thick cheese cloth, rinse, and bring total volume to 600 mL in a graduated cylinder. The solution will be cloudy. Record exact volume. Use pH paper to test pH of filtrate. If pH is below 7.0 or above 10.0, adjust with 1 M NaOH or 0.5 M  $\text{H}_2\text{SO}_4$ , respectively. The filtrate should be stored in a refrigerator. To prevent mold, add a few crystals of thymol or a few drops of Lysol disinfectant. *WORD OF WARNING: Pretzels are suitable, but potato chips and cheese-flavored snacks are difficult to filter.*
2. Solution preparation:
  - a.  $\text{AgNO}_3$  solution, 0.0141 M: Dissolve 2.40 g  $\text{AgNO}_3$  (dried overnight at 140 °C) in chloride-free water and dilute to 1.00 L. Store in a brown bottle.
  - b.  $\text{K}_2\text{CrO}_4$  indicator solution: Dissolve 10 g  $\text{K}_2\text{CrO}_4$  in a little distilled water. Add  $\text{AgNO}_3$  solution until a definite red precipitate is formed. Allow to stand 18-24 hr, filter, and dilute filtrate to 200 mL with distilled water. Put into dropper bottles.

## LABORATORY ACTIVITY: TEACHER NOTES



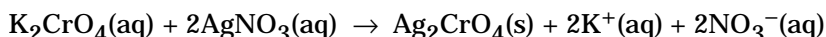
- c. 1 M NaOH: Dissolve 4 g in distilled H<sub>2</sub>O and dilute to 100 mL.
  - d. 0.5 M H<sub>2</sub>SO<sub>4</sub>: Dilute 3 mL 18 M H<sub>2</sub>SO<sub>4</sub> to 100 mL—carefully!
  - e. 0.01 M NaCl: 0.06 g NaCl per 100 mL solution.
3. Assume that 1.0 mL AgNO<sub>3</sub> solution  $\approx$  0.825 mg NaCl

(0.0141 mol Ag<sup>+</sup>  $\approx$  0.0141 mol NaCl from equation.)

$$0.0141 \text{ mol NaCl} \times \frac{58.5 \text{ g NaCl}}{\text{mol NaCl}} = \frac{0.825 \text{ g NaCl}}{\text{L}} = 0.825 \text{ mg/mL}$$

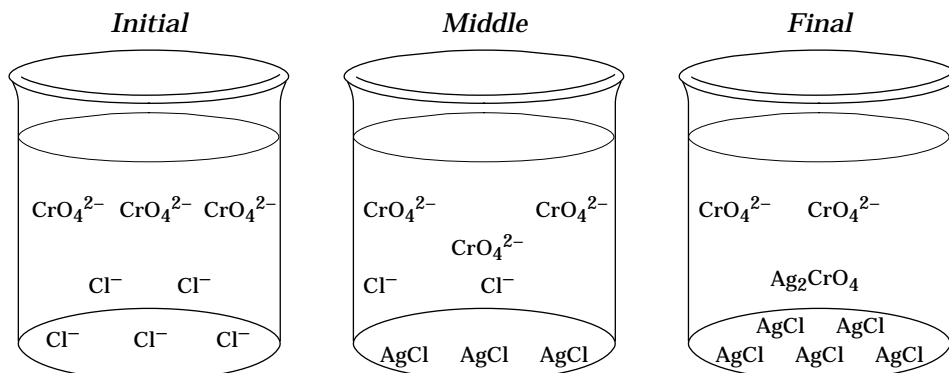
### Pre-Laboratory Discussion

1. Discuss the dangers of too much salt in our diet. [*Hypertension, kidney disease, heart disease*]
2. Show Fritos® package, read list of ingredients and all nutritional information on label. Make overhead projection of label. Point out the amount of “sodium” on the label. Discuss with students: Is this metallic, elemental sodium or sodium in the form of a compound? [*Na ions.*] How can we determine the actual amount of NaCl present? [*By dissolving the salt in H<sub>2</sub>O and analyzing for one of the ions.*]
3. Explain that these reactions are the basis of Mohr chloride analysis. It depends on the solubility of the two silver precipitates, AgCl and Ag<sub>2</sub>CrO<sub>4</sub>. If Ag<sup>+</sup> ion is added to a solution containing *both* Cl<sup>-</sup> and CrO<sub>4</sub><sup>2-</sup> ions, the AgCl will be precipitated first, because it is “less soluble in water” than the Ag<sub>2</sub>CrO<sub>4</sub>. The solubility concentrations are AgCl = 1.3 x 10<sup>-5</sup> M, and Ag<sub>2</sub>CrO<sub>4</sub> = 1.3 x 10<sup>-4</sup> M. When all the chloride ion has been precipitated, the Ag<sub>2</sub>CrO<sub>4</sub> starts to precipitate and the color changes from a creamy yellow to an orange almost like orange juice. This end-point is somewhat subjective, and students should keep all titration flasks for comparison until they finish at least three trials.
4. Show the reactions below. AgCl(s) is white; Ag<sub>2</sub>CrO<sub>4</sub>(s) is red.



Use a beaker or flask to illustrate the above reactions. Take 10 mL 0.01 M NaCl solution; add 20 drops of K<sub>2</sub>CrO<sub>4</sub> solution; note color. Then add the AgNO<sub>3</sub> solution, dropwise, with swirling. Point out the color changes to the orange color that signals the end-point of the titration.

5. Discuss the reason for using a blank. A blank is used to correct for any chloride ion that may be present in the water being used. It normally has a value of about 0.2-0.3 mL, and must be subtracted from the amount of AgNO<sub>3</sub> solution used in the analysis of the sample.
6. Make sure that students understand the proper use of burets, how to fill them, and read the volume. Stress that they must rinse the burets 4-5 times with distilled water when the laboratory is over.
7. Review the proper use of transfer pipets and demonstrate prior to student use.
8. The following “Pictures in the Mind” can be used to develop an understanding of the phenomena occurring during titration.



### Teacher-Student Interaction

1. What is the purpose of the “blank” in the titration? *[The blank is necessary because some chloride may be present in the distilled or deionized water. The value normally is only 0.2-0.3 mL.]*
2. Why is the blank value subtracted from the total  $\text{AgNO}_3$  solution used? *[The blank value is subtracted from the total  $\text{AgNO}_3$  used in order to correct for any chloride ions present in the water used to make the filtrate.]*
3. What are possible explanations for the chloride ion being present in the blank? *[If deionized water is used, some chloride could be present from ion exchange; or glassware may not be completely rinsed.]*
4. As students titrate, ask them to notice the red  $\text{Ag}_2\text{CrO}_4$  forming and then disappearing with swirling. Get them to explain the process. *[The  $\text{Ag}_2\text{CrO}_4$  forms and then dissolves as the  $\text{AgCl}$  precipitates preferentially because of its lower solubility.]*
5. Suggest that students keep the blank flask to compare with subsequent trials. This reference will help them be consistent in judging the end-point. It is helpful to keep all titration flasks lined up for color comparison. This makes it easy for the student to see if too much  $\text{AgNO}_3$  has been added.

### Anticipated Student Results

Average mL  $\text{AgNO}_3$  used for the blank: 0.3 mL

Average mL  $\text{AgNO}_3$  used for the sample: 7.3 mL

Mass of Fritos® used: 20.0 g

Total volume of filtrate: 600.0 mL

### Answers to Data Analysis and Concept Development

$$3. \frac{(\text{avg mL AgNO}_3 \text{ used} - \text{blank})}{10 \text{ mL filtrate}} \times \frac{0.825 \text{ mg NaCl}}{1 \text{ mL AgNO}_3} = \frac{5.77 \text{ mg NaCl}}{10 \text{ mL filtrate}}$$

$$\frac{5.77 \text{ mg NaCl}}{10 \text{ mL filtrate}} \times \frac{600.0 \text{ mL filtrate}}{20.0 \text{ g Fritos®}} = \frac{17.3 \text{ mg NaCl}}{1 \text{ g Fritos®}}$$



## Answers to Implications and Applications

1. The National Research Council has defined an “adequate and safe” level of sodium as between 1000 and 3300 mg daily. Some physicians feel that this is too high and should be much lower, around 220 mg per day.
2. Answers will vary (see *Assessing Laboratory Learning*, Question 2, for a sample calculation).
3. Monitor the amount of salt in the diet.

## Post-Laboratory Discussion

1. Make sure that students have calculated their analytical data correctly and averaged their results. Put class values on the board for comparison and discussion.
2. Assist students in calculating mg NaCl in the entire Fritos® package. Food values are given as “mg sodium,” not “mg sodium chloride.” Show students how to convert mg NaCl to mg Na.

$$\text{By ratio: } \frac{\text{molar mass NaCl}}{\text{molar mass Na}} = \frac{\text{mg NaCl}}{\text{mg Na}}$$

$$\text{Unit Analysis: } \text{mg Na} \times \frac{\text{molar mass NaCl}}{\text{molar mass Na}} = \text{mg NaCl}$$

3. Discuss discrepancies between the stated value and the experimental results.
4. Ask teams of students to make an estimation of one person’s daily intake of sodium, using information from library sources such as *Composition of Foods* (U.S. Department of Agriculture, 1979).

## Extensions

1. The Mohr Chloride analysis can be used for pretzels, potato chips, and other salty snack foods.
2. Analyze tap water, bottled spring water, and pond or stream water for chloride content.

## Assessing Laboratory Learning

1. When a sample of pretzels was analyzed by the Mohr chloride method, the following data was obtained:

Average mL for blank: 0.2 mL

Average mL for sample: 13.5 mL

Mass of pretzels used: 10.0 g

Total filtrate volume: 300.0 mL

Calculate the mg NaCl and the mg Na in a 1 ounce (28.4 g) serving of these pretzels.



$$\frac{13.5 \text{ mL} - 0.2 \text{ mL}}{10 \text{ mL filtrate}} \times \frac{0.825 \text{ mg NaCl}}{1 \text{ mL AgNO}_3} = \frac{11.0 \text{ mg NaCl}}{10 \text{ mL filtrate}}$$

$$\frac{11.0 \text{ mg NaCl}}{10 \text{ mL filtrate}} \times \frac{300.0 \text{ mL filtrate}}{10.0 \text{ g pretzels}} = \frac{33.0 \text{ mg NaCl}}{1 \text{ g pretzels}}$$

$$\frac{33.0 \text{ mg NaCl}}{1 \text{ g pretzels}} \times 28.4 \text{ g pretzels} = 937 \text{ mg NaCl}$$

$$937 \text{ mg NaCl} \times \frac{23.0 \text{ mg Na}}{58.5 \text{ mg NaCl}} = 368 \text{ mg Na}$$

2. The following information was given on a snack label:

Package weight: 10 oz (283 g)

Serving size: 1/2 oz

Sodium per serving: 90 mg

- a. Calculate the mg NaCl per serving.

$$\frac{90 \text{ mg Na}}{\text{serving}} \times \frac{58 \text{ mg NaCl}}{23 \text{ mg Na}} = \frac{227 \text{ mg Na}}{\text{serving}}$$

- b. Calculate the grams of NaCl and teaspoons of NaCl in the entire package (1 teaspoon NaCl = 6 g).

$$\frac{0.227 \text{ g NaCl}}{0.50 \text{ oz}} \times \frac{10 \text{ oz}}{\text{package}} = \frac{4.54 \text{ g NaCl}}{\text{package}}$$

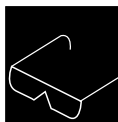
$$\frac{4.54 \text{ g NaCl}}{\text{package}} \times \frac{1 \text{ tsp NaCl}}{6.0 \text{ g NaCl}} = 0.76 \text{ tsp NaCl}$$

3. Obtain information from labels on products in the grocery store concerning the sodium content of the following: cookies, hot cereals, soda crackers, canned vegetables, dry cereals, canned fruit, popcorn, cheese-flavored snacks.

Which of these foods would be recommended for a low-sodium diet? Compare the salt content of normal prepared spaghetti sauce with the low sodium variety.



## LABORATORY ACTIVITY: STUDENT VERSION



### **Activity 2: Chromatographic Comparison of M&M™ Candies with Reese's Pieces™**

#### **Introduction**

Colors in candies are due to synthetic dyes that have been approved by the Food and Drug Administration (FDA). Sometimes the colors such as greens and browns are mixtures of several dyes. In this laboratory we will separate the colors in M&M™ candies and Reese's Pieces™ by means of paper chromatography. Differences in the solubilities of the dyes will enable us to make the separation. The more soluble dyes will travel up the paper faster than dyes that are less soluble.

#### **Purpose**

To determine if the brown coloring matter in M&M™ candies is the same as the brown coloring matter in Reese's Pieces™. At the same time, other candy colors will be chromatographed to determine their component colors.

#### **Safety**

1. Wear protective goggles throughout the laboratory activity.
2. Do not eat any of the candy used in the laboratory activity.

#### **Procedure**

1. Obtain 3-4 brown M&M™ candies (or whatever color your teacher assigns). Place them in a small evaporating dish and place a few drops of tap water on them. Stir around with a toothpick to dissolve the color. As soon as the colored layer is dissolved, remove the piece from the dish with forceps and discard them.
2. Repeat with some brown Reese's Pieces™ in a second evaporating dish. Use clean toothpicks for each dish.
3. Obtain a piece of chromatography paper that will accommodate spots of both candy colors. Draw a light *pencil* line about 3 cm from the bottom edge of the paper and initial the paper in one upper corner. Put two pencil dots on the original pencil line, about 3 cm apart. Label one M&M™ and one Reese's Pieces™.
4. Using small capillary tubes place spots of each color on the labeled dot. The spots should be about 1 cm in diameter, and must not overlap. Let dry and apply more sample, keeping the spots as small as possible. Repeat until you have placed about 5-6 spots on each dot to make a concentrated sample.
5. Obtain the proper container for the chromatography (beaker or jar) and pour in salt solution until it is about 1 cm deep. Suspend the paper in the container as your instructor directs (see *Forensic Chemistry* module, Activity 1). Be sure that the lower end of the paper is just touching the solution, and that the solution does not reach the colored spots.
6. When the solution rises to within 3 cm of the top of the paper, remove the paper from the solution and allow to dry. Mark the position of the solution on the paper with a light pencil line.
7. Compare the chromatograms for each dye to determine if the candies contain the same dyes.
8. Thoroughly wash your hands before leaving the laboratory.

### **Data Analysis and Concept Development**

Notice the number and colors of the spots on the two chromatograms. Draw circles around the spots that are common to the two candies. The spots must be the same color and must have traveled the same distance up the paper.

1. Is a pure brown dye used to color the candies?
2. If you wished to produce a green dye, what colors would you use?
3. Suppose you were given an unmarked bag of one of these candies. How could you distinguish chemically whether the contents were M&M's™ or Reese's Pieces™?

### **Implications and Applications**

1. How could chromatography be used to distinguish some look-alike candies?
2. How could you tell which dyes were present in the candies?



**LABORATORY  
ACTIVITY:  
TEACHER  
NOTES**

***Activity 2: Chromatographic Comparison of  
M&M™ Candies with Reese's Pieces™***

**Major Chemical Concept**

Paper chromatography can be used to separate the food colors in candy such as M&M™ candies and Reese's Pieces™, and can show the differences between the brown colors in the two brands.

**Level**

This activity is appropriate for all levels of chemistry classes.

**Expected Student Background**

None

**Time**

50-55 min. The activity can be broken into two 30-min time periods by doing Steps 1-4 on the first day and storing the prepared samples for later use.

**Safety**

Read the *Safety Considerations* in the *Student Version*.

**Materials** (For 24 students working in pairs)

**Nonconsumables**

- 12 Chromatography jars with lids or stoppers (empty 12-16 oz jelly or spaghetti sauce jars)
- 12 Forceps
- 12 Lead pencils
- 12 Ringstands and buret clamps

**Consumables**

- 36-48 Pieces of each color and kind of candy
- 12 Chromatography paper (or filter paper) pieces cut to fit containers to be used (e.g., 4 cm x 8 cm)
- 24 Capillary tubes
- Water, distilled
- 0.1% NaCl solution (dissolve 0.5 g NaCl in about 500 mL water)

**Advance Preparation**

Obtain the necessary amount of candy. Cut chromatography paper to fit containers. Prepare suspension apparatus for chromatography jars or tubes. A paper clip hook inserted in a cork is ideal for large test-tubes (see *Forensic Chemistry* module for diagram). Have a sample setup ready for students to use as a model.

**Pre-Laboratory Discussion**

Show an example of a chromatographic separation (such as the ink from a washable black marker or pen), and explain how paper chromatography can separate the colors. For use in foods, there are only 5 or 6 artificial colors that are approved by the Food and Drug Administration (FDA). A mixture of colors is required to give a brown color. Show students the candy and ask them if they think that the brown colors in each brand are made of the same mixture of colors. Paper chromatography will provide the answer.

### Teacher-Student Interaction

Circulate in the laboratory. Check spots on prepared chromatograms to make sure they are properly placed and not too large.

### Anticipated Student Results

The brown color is a mixture of red and blue dyes.

### Answers to Data Analysis and Concept Development

1. No, blue and red.
2. Yellow and blue.
3. Carry out a chromatographic analysis using the M&M<sup>TM</sup> candies and Reese's Pieces<sup>TM</sup> along with the unknown. Check the chromatogram for a match.

### Answers to Implications and Applications

1. Use paper chromatography to separate and compare the dyes used in the candies. Make sure that students are aware that there are only five or six food colors approved by the Food and Drug Administration (FDA), so some look-alike candies may indeed have chromatograms that look alike as well.
2. Obtain food dye samples of known composition to use as standards. A convenient source is the food colors sold in supermarkets since each color is labeled with the dye or dyes that it contains. Chromatographing these dyes side by side with the candy samples will probably help identify the candy dyes.

### Post-Laboratory Discussion

Discuss this laboratory activity in terms of separation (see *Separations* module). Ask students why they think separations are so important to chemists. Ask students to suggest ways in which separations can be used in the food industry. Ask them to imagine that they are trying to break into a candy market that has been dominated by a certain manufacturer. What chemical information might they need? How can they obtain this information? How can the concept of chromatographic separations help? Explain that there are numerous commercial analytical laboratories that perform some of these functions for businesses. Also pertinent to this laboratory activity is the fact that Red (Dye) No. 3, used in fruit cocktail cherries, is being phased out by the FDA because extensive tests showed that this dye could cause thyroid cancer in rats. Ask students to discuss a way for testing for Red No. 3 in various food products. What products might they choose? Do these products necessarily have to be red? (See *Extensions*.)

### Extensions

1. Students may wish to examine products at home or in the grocery store to find out which ones contain Red No. 3. Boxes of food colors state that they contain Yellow No. 5, Red No. 40, Red No. 3, and Blue No. 1. Students can use paper chromatography to determine the ingredients of green, red, and yellow colors. There are many other foods that can be chromatographed, such as numerous varieties of candy, diet Jello<sup>TM</sup>, or Kool-Aid<sup>TM</sup>. Washable colored pens are advertised as using only FDA approved colors, but do they? Design an experiment to verify or disprove these claims.
2. Do Activity 1 in the *Forensic Chemistry* module on identifying over-the-counter drugs by chromatography.



## **References**

- Red No. 3 and other colorful controversies. (1990, May). *FDA Consumer*, 24(4).
- Additives for eye appeal. (1973, July-August). *FDA Consumer*.

## **Assessing Laboratory Learning**

1. Draw representative chromatograms. Show how an unknown can be identified from a chromatogram.
2. Give students two chromatograms and have them identify the substance(s) common to both.

**Activity 3: Analysis of Milk****Introduction**

Milk is the complete food. It contains all of the major food groups required to meet the body's needs. You will analyze milk to determine the relative amounts of water and the three food groups—fats, proteins, and carbohydrates—contained in a typical milk sample.

**Purpose**

To determine the composition of milk.

**Safety**

1. Wear protective goggles throughout the laboratory activity.
2. The extraction solvent fumes are volatile and harmful. Use under a fume hood or in a well-ventilated room.
3. Do not use mouth suction when filling pipets. Always use a pipet bulb. Your teacher will instruct you in its use.
4. When heating liquids, add boiling chips to avoid “bumping.”
5. Dispose of excess liquids and solids as directed by your teacher.
6. Carefully read the laboratory activity before coming to the laboratory. Think about what you are going to do and plan ahead.

**Procedure****Day 1****Part 1: Extracting and Determining the Percentage of Milk Fat in Milk**

1. Weigh an empty 250-mL Erlenmeyer flask to  $\pm 1$  g. Record mass in data table.
2. Using a graduated cylinder, add 100 mL milk to the flask and weigh again. Record mass in data table.
3. Using a second 100-mL graduated cylinder, add 100-mL nonpolar solvent (to be specified by your teacher) to the milk sample. Stopper the flask tightly.
4. Mix the flask contents for about 1 min by gently but repeatedly turning the flask over. Avoid vigorous shaking to prevent formation of small fat globules. The small globules increase the fatty material's surface area and trap nonfat materials in the fatty layer.
5. After mixing, allow the mixture to settle until the two layers are separated. The top layer is the nonpolar solvent layer; it contains the fat-soluble components of milk. The bottom layer is the aqueous layer; it contains the water-soluble components of milk.
6. Weigh a 250-mL beaker to  $\pm 1$  g and record its mass in the data table.
7. Using a pipet, remove the aqueous (bottom) layer by successively withdrawing the liquid and transferring it into the weighed 250-mL beaker. The last portion can be withdrawn by having your partner tip the flask about 45 degrees to concentrate the remaining volume of water-soluble layer in the bottom of the flask and then carefully withdrawing as much as you can without mixing it with the nonpolar solvent layer.

**LABORATORY  
ACTIVITY:  
STUDENT  
VERSION**



8. Weigh the 250-mL beaker containing the aqueous layer and record the mass.
9. Using these data, calculate the percent milk fat in the original milk sample. Save bottom layer for use in Part 2; discard waste materials as directed by your teacher.

### ***Part 2: Removal of Milk Protein***

1. Add approximately 100 mL vinegar to the aqueous layer from Part 1, Step 8. Stir the sample slowly until solid clumps appear in the liquid.
2. Weigh a piece of filter paper and record mass in your data table.
3. Place the filter paper in a Buchner funnel fitted to a suction flask, wet it with a little distilled water and suction filter the coagulated material in the beaker. Continue to apply suction for about 5 min after all the liquid has passed into the suction flask; this strategy will help in drying your coagulated sample.
4. Carefully remove the filter paper and contents from the Buchner funnel and place on a watch glass that has been previously marked with your initials. Allow the filtered material, which consists largely of milk protein, to dry overnight.
5. Dispose of the liquid in the suction flask as directed by your teacher.
6. Thoroughly wash your hands before leaving the laboratory.

## **Day 2**

### ***Part 3: Determination of Percentage of Milk Protein***

1. Weigh filtered, dried milk protein plus filter paper and record mass in data table.
2. Calculate the percent protein in the original milk sample.

### ***Part 4: Determination of Percentages of Water and Carbohydrates in Milk***

1. Weigh a small evaporating dish (the size should be large enough to be seated on top of a 250-mL beaker) and stirring rod together to  $\pm 0.1$  g. Record mass in data table.
2. Using a 10-mL graduated cylinder, add 5 mL fresh milk to the evaporating dish and weigh again. Record mass in data table.
3. Set up a ringstand, ring, wire gauze and burner. Half fill a 250-mL beaker with water, add a few boiling chips, and place on the assembly.
4. Place the evaporating dish and contents on top of the 250-mL beaker from Step 3. Heat the water in the beaker to slowly evaporate the liquid from the milk sample. As a thin layer of scum forms on the milk, break it up with the stirring rod, making sure that you keep the stirring rod inside the dish. Stir the milk gently and continuously to avoid scorching.
5. As the milk dries, it becomes pasty. When the paste consistency appears to remain constant for a few minutes, stop heating. Allow the dish to cool. Wipe the condensed water from the outside of the dish. The dish now contains the milk solids.
6. Weigh the dish, stirring rod and milk solids, and record mass in your data table.
7. From these data, calculate the percent water in the original milk sample.



8. Knowing the percentages of fat, protein, and water contained in milk, calculate the percent carbohydrate by difference. Assume that the major components of milk are fat, protein, water, and carbohydrates only.
9. Thoroughly wash your hands before leaving the laboratory.

## Data Analysis and Concept Development

### Data Table

#### Part 1

Mass of flask + 100 mL milk	(g)
Mass of flask	(g)
Mass of 100 mL milk	(g) [A]
Mass of 250-mL beaker + aq. layer	(g)
Mass of beaker	(g)
Mass of aqueous layer	(g) [B]
Mass of fat extracted [A - B]	(g) [C]

#### Parts 2 and 3

Mass filter paper + milk protein	(g)
Mass filter paper	(g)
Mass milk protein	(g) [D]

#### Part 4

Mass evaporating dish, stirring rod, and milk before heating	(g) [F]
Mass evaporating dish, stirring rod	(g) [E]
Mass of milk [F - E]	(g) [G]
Mass evaporating dish, stirring rod, and milk solids after heating	(g) [H]
Mass of milk solids [H - E]	(g) [J]
Mass of water evaporated [G - J]	(g) [K]

1. From your data, calculate:

	Laboratory value	Average accepted value
Percent milk fat (C/A) x 100	%	3.3%
Percent milk protein (D/A) x 100	%	3.3%
Percent water in milk (K/G) x 100	%	88%
Percent milk carbohydrate	%	4.5%



2. Compare your milk analysis with actual amounts listed on a carton of milk.
  - a. Can you account for any difference between your results and the listed values?
  - b. Why do you think that these average values do not total 100%?
  - c. Explain why your laboratory values total 100%.
3. In Part 1, Step 3, why did you use a nonpolar solvent to extract milk fat?
4. In Part 1, Step 4, what effect would trapping of nonfat milk content in the fat-soluble layer have on your results?
5. In Part 1, Step 7, what effect would extracting some of the top layer along with the bottom layer have on your results?
6. In Part 2, Step 1, why does vinegar coagulate the protein?
7. In Part 4, Step 1, why did you weigh the stirring rod along with the evaporating dish?
8. In Part 4, Step 4, why did you heat the milk over water? What effect would losing some of the milk solid have on your results?

### **Implications and Applications**

1. Powdered milk is primarily composed of the milk proteins and carbohydrates. Calculate the percent composition of powdered milk from the previous data. Would powdered milk be a good high protein supplement to add to other foods?
2. Have you ever accidentally poured orange juice into milk at breakfast? What happened? Why?
3. In the introduction, milk was discussed as a complete food. Can you name the principal proteins and carbohydrates in milk?
4. We have studied whole milk. There are other types of milk like 2% milk, 1% milk, and skim milk. What do these names imply about the milk composition?

### Activity 3: Analysis of Milk

#### Major Chemical Concept

The methods for extraction of milk components are based upon their chemical differences:

**Fats:** Extraction from a polar emulsion with a nonpolar solvent.

**Proteins** Precipitation by denaturation.

**Water:** Evaporation.

**Carbohydrates** By difference.

#### Level

For all levels of high school chemistry.

#### Expected Student Background

Students should be familiar with the properties of fats, proteins, and carbohydrates.

#### Time

Two 50-min periods. It is not necessary for the laboratory periods to be on consecutive days.

#### Safety

1. Read the *Safety Considerations* in the *Student Version*.
2. The nonpolar solvent is volatile and has hazardous fumes.

#### Materials (For 24 students working in pairs)

##### Part 1

##### **Nonconsumables**

- Balances
- 24 Graduated cylinders, 100-mL
- 12 Erlenmeyer flasks, 250-mL
- 12 Stoppers to fit flasks
- 12 Transfer pipets and bulbs (size appropriate for extracting in steps 100 mL aqueous layer from milk sample); alternatively, separatory funnels
- 12 Beakers, 250-mL

##### **Consumables**

- Fresh Whole Milk, 1.2 L
- Nonpolar solvent, 1.2 L (see *Advanced Preparation*, Part 1)

##### Parts 2 and 3

##### **Nonconsumables**

- 12 Buchner funnels, suction flasks; alternatively, funnels, *fluted* filter paper
- 12 Spatulas
- 12 Beakers, 250-mL
- 12 Watch glasses

##### **Consumables**

- Aqueous layer (from *Part 1*) in 250-mL beaker
- Vinegar, 1.2 L
- 12 Filter papers (to fit Buchner funnel)

## LABORATORY ACTIVITY: TEACHER NOTES



## Part 4

### ***Nonconsumables***

12 Graduated cylinders, 10-mL  
12 Evaporating dishes  
12 Glass stirring rods  
12 Beakers, 250-mL  
12 Ringstands  
12 Ring clamps  
12 Wire mesh  
12 Burners

### ***Consumables***

Milk, 60 mL  
Boiling chips

## Advance Preparation

### Part 1

1. Purchase fresh whole milk. (Lowfat milks do not work very well.) Check the label on the carton to see if the declared values match those given to students in the data table. Adjust accordingly.
2. Use separatory funnels if they are available instead of the pipets in Part 1, Step 7.
3. Possible nonpolar solvents include trichlorotrifluoroethane (TTE), hexane, cyclohexane, and dichloromethane. Consider the hazards and cost for using each solvent. *NOTE: TTE is available as DuPont TF Solvent from dry-cleaning supply companies; this technical grade solvent is considerably less expensive than higher-grade TTE found in some chemical supply catalogs. Mix equal amounts (1 mL) of each nonpolar solvent and water to determine position of water layer.*

### Part 2 and 3

1. A Buchner funnel and aspirator is ideal for the filtration of the protein. If not available, filter material through *fluted* filter paper to hasten filtration.
2. If filter paper is used, remember to remove the filter paper containing the protein from all students' funnels for overnight drying at the close of the first day. Set them on paper towels to dry overnight. Try not to leave the protein sample in one large clump (low surface area retards drying). Spread the protein thinly on the filter paper with a spatula. Leave the appropriate beaker and filtrate next to each filter paper.
3. Air drying will not remove all the water from the protein. However, the mass of the water remaining is not large enough to affect the students' results in any significant way. If desired, the protein could be given a final wash with ethanol to hasten drying.
4. Only the casein fraction of the protein is removed during protein extraction. The whey proteins ( $\beta$ -lactoglobulin and  $\alpha$ -lactalbumin) are not precipitated. Thus it is incorrect to claim that this procedure measures "all" milk protein. However, since casein is the major protein in milk, student results will be quite acceptable.

#### Part 4

1. The stated procedure in Part 4 is not a very effective way to remove the moisture from the milk sample, but it has been bench tested and has produced good results. However, you can consider using a small convection oven if one is available.

#### Pre-Laboratory Discussion

Discuss solvent extraction, polar and nonpolar solvents, two layers and how to know which is which. Discuss precipitate formation, evaporation of a liquid and the effects of heat on the rate of evaporation.

#### Teacher-Student Interaction

Circulate in the laboratory. Demonstrate use of pipet bulb. Buchner funnels will be new to students; show them how to remove filter paper from the funnel.

#### Anticipated Student Results

1. Laboratory values to be expected:
2. a. The reported values are averages. Each sample of milk will vary from the average values. Experimental error can account for some of the differences: balance accuracy and precision, extraction errors, *etc.*
- b. The average values do not total 100% because of the uncertainties in the reported values and the presence of small quantities of other components, such as vitamins and minerals.
- c. Student values total 100% because the carbohydrate value was obtained by subtracting the total of the other measurements from 100. The assumption was made that the contribution of the other components in milk was negligible and that the carbohydrate percentage could be determined indirectly by difference.
3. Fats are nonpolar and dissolve more readily in nonpolar solvents.
4. The extraction of nonfat milk components would be incomplete and yield high results for the percentage of milk fat.
5. Some of the fat-soluble layer would be weighed with the bottom layer and give low results for the percentage of milk fat.
6. Acids cause denaturation of proteins (see *Enzymes* module). Proteins lose their three-dimensional configuration that allows them to be water-soluble, and they precipitate out of solution.
7. The milk solid residue will collect on the stirring rod while stirring the mixture. Since it would be impossible to remove all of the solids from the rod in order to weigh the residue, the weight of the rod is counted from the beginning to minimize the error from this experimental step.
8. The milk would char or burn if subjected to extreme temperatures such as the direct flame of a burner. Losing some of the milk solid would cause a higher percentage of water to be reported.

Percent milk fat	2.7 - 4.1%
Percent milk protein	2.8 - 4.0%
Percent water	85 - 92%
Percent carbohydrate	3.5 - 5.5%



## Answers to Implications and Applications

1.  $3.3 \text{ g (protein)}/7.8 \text{ g (total protein + carbohydrate)} = 42\%$  protein. Powdered milk qualifies as a high protein supplement due to the large amount of protein per unit mass.
2. Milk proteins curdle in acid. Orange juice is acidic and can curdle (aggregate) protein.
3. Casein (protein) and lactose (carbohydrate).
4. The percent composition of fat in the milk.

## Post-Laboratory Discussion

Look at the different types of milk and show the different contents. Some examples are 2%, skim, evaporated, powdered, baby formula, goat milk, and deer milk. Discuss the advantages and disadvantages of each type of milk.

## Extensions

1. Extend this concept to the energy and nutritional value of milk. Calculate the calories in milk using the results of the activity (protein or carbohydrate = 4 cal/g; fat = 9 cal/g). Look at the minerals and vitamins in milk and check if they have been added as part of the fortification of milk.
2. Bromine is decolorized by unsaturated fats. Have students do library research on the degree of unsaturation of fats in milk and report on it in the context of other fatty foods.

## Assessing Laboratory Learning

1. Ask students to explain why the mineral and vitamin content is considered insignificant in the determination of milk composition.
2. Ask students to list several common substances that they would expect to coagulate milk, and to explain why.
3. Ask students why we extracted and weighed the aqueous layer if they were determining fat content, which was contained in the fat-soluble layer.

## DEMONSTRATIONS

*CAUTION: Use appropriate safety guidelines in performing demonstrations.*

### Demonstration 1: “Light” Margarine, Paying More for Less

#### *Purpose*

To demonstrate the amount of water in regular, light, and “extra light” margarines.

#### *Materials*

Three kinds of margarine from one manufacturer (*i.e.*, Regular, Light, and Extra Light Fleischmann’s margarine)  
3 Graduated cylinders, 10-mL (glass, heat-resistant)  
3 Beakers, 100- or 250-mL (glass, heat-resistant)  
3 Stirring rods  
Balance  
Hot plate or burner

### Procedure

Prepare ahead of time:

1. Melt 10 g of each margarine in separate beakers. Heat gently, stir constantly; do not allow to boil.
2. While stirring continuously, pour each sample of melted margarine into a labeled 10-mL graduated cylinder, filling exactly to the 10.0-mL mark. Allow to cool. Keep covered and refrigerated until ready to perform the demonstration.
3. Photocopy (or type) the nutritional labels from each kind of margarine and make overhead projections (OHPs) and/or copies for the students.

The demonstration:

1. Show the margarine packages. Show the OHPs and/or hand-outs and point out that the amount of fat *is* decreasing (just as the ads say), along with the calories, as one compares the different margarines: Regular → Light → Extra Light.
2. What is the *first* ingredient listed in each label? [*In Regular and Light, it is "liquid corn oil," but in Extra Light, it is water.*]
3. Show the students the prepared graduated cylinders, with the layer of water on the bottom of each. A light box or diffused light source behind the tubes will make the layers clearly visible. (One could also make a drawing on the OHP, showing the amount of water in each product.)
4. List the percent water found by examining the graduated cylinders:

Regular	3%
Light	20%
Extra Light	35%

(NOTE: There is a white layer between the water and the oil layers; this is probably the whey that is listed in each ingredient list. )

5. Discussion (the discussion of Topics f and g could lead to several student projects):
  - a. Reasons why consumers buy Light and Extra Light.
  - b. How many of the students use these products at home.
  - c. What is the cost/pound for each type? (Recent purchase of Fleischmann's Regular = \$1.29; Light = \$1.39; Extra Light = \$1.79)
  - d. Why do Light and Extra Light cost more, even though they contain less fat and more water?
  - e. What is the cost/pound of the actual fat in each margarine?
  - f. What two types of fats are listed on the label? Why do they *not* add up to the total amount of fat in the margarine? What other kind of fat is present?
  - g. Saturated vs. unsaturated fat controversy: What is the effect of dietary saturated fat on blood cholesterol levels?

### Extensions

Have the students bring in samples of other margarines, butter, "soft butter," and butter "taste-alikes" to test for water content.



## Demonstration 2: Extraction of Iron from Cereal: The Oxidation States of Iron

### *Purpose*

To extract iron from cereal and determine its oxidation state. Elemental iron in the form of minute iron filings can be extracted from cereal with a magnet. To dissolve the extracted iron in simulated stomach acid and determine its oxidation state. When dissolved in 0.1 M HCl, both the Fe(II) and Fe(III) oxidation states are obtained.

### *Materials*

Nabisco Instant Cream of Wheat (individual serving packets work best)  
Beakers  
Test-tubes  
Magnetic stir bar and stirrer  
0.1 M HCl [simulated stomach acid; 4 mL conc. HCl (12 M) to 500 mL solution]  
0.1 M KSCN Potassium thiocyanate [Add 0.97 g KSCN to water and dilute to 100 mL]  
0.1 M  $\text{K}_4\text{Fe}(\text{CN})_6$  Potassium ferrocyanide [Add 3.7 g  $\text{K}_4\text{Fe}(\text{CN})_6$  to water and dilute to 100 mL]  
0.1 M  $\text{K}_3\text{Fe}(\text{CN})_6$  Potassium ferricyanide [Add 3.3 g  $\text{K}_3\text{Fe}(\text{CN})_6$  to water and dilute to 100 mL]  
0.1 M Fe(II) Salt such as  $\text{FeSO}_4$  or  $\text{Fe}(\text{NH}_4)_2(\text{SO}_4)_2$  [Add 0.01 mole of either to water and dilute to 100 mL]  
0.1 M Fe(III) Salt such as  $\text{FeCl}_3$  or  $\text{Fe}(\text{NO}_3)_3$  (Add 0.01 mole of either to water and dilute to 100 mL)

### *Safety*

Use normal safety precautions.

### *Procedure*

Show boxes of cereals and note the ingredient listing for iron. This listing could read “iron,” “elemental iron,” “reduced iron,” or some iron compound [usually Fe(II)]. “Reduced iron” is elemental iron. Explain to students that in order for iron to be absorbed in the intestines, it must be in the Fe(II) state. Ask them how we could get the iron out of the cereal. What forms of iron could be removed with a magnet?

Extract the iron by crushing and stirring the dry cereal with the stir bar for about 5-10 min. Extract the stir bar from the cereal. Let students examine it. They will note the iron “whiskers” clinging to the bar. Place the stir bar in a beaker with 100 mL 0.1 M HCl. Explain that the sample has to stand several days in order for the iron to dissolve. Compare the pH of the HCl to that of the stomach. Compare the conditions of the demonstration with that of iron in the stomach, *e.g.*, temperature, agitation, and time in the HCl solution. The stomach empties about every 2-3 hr.

Cover the beaker and examine it every day for a week. Point out that the iron has dissolved. Ask what compound is present. Students will say iron chloride. But which one?

In test-tubes, show the reactions of known iron salts with the reagents, making a table as shown. Using these results, determine the oxidation state of iron dissolved in the acid.

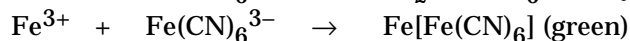
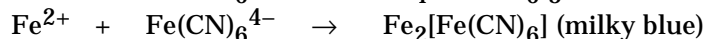
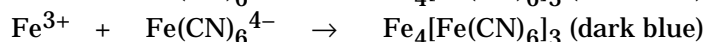
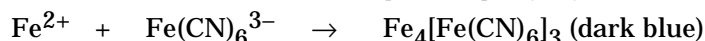


	KSCN	K <sub>4</sub> Fe(CN) <sub>6</sub>	K <sub>3</sub> Fe(CN) <sub>6</sub>
Fe <sup>2+</sup> solution	—	Milky blue	Dark Blue
Fe <sup>3+</sup> solution	Red	Dark blue	Clear green
Dissolved iron solution	Red	Dark blue	Dark blue

#### Remarks

The following questions might be used in discussing the demonstration:

1. What is the oxidation number of Fe in K<sub>4</sub>Fe(CN)<sub>6</sub>? [+2]/In K<sub>3</sub>Fe(CN)<sub>6</sub>? [+3]
2. Write balanced equations for each color of solution or precipitate formed in the tests.



3. From your observations, draw a conclusion about the oxidation number of the iron dissolved in the HCl. Write formula(s) and name(s) for the compound(s) formed. *[Both will be present: FeCl<sub>2</sub>, iron(II) chloride, and FeCl<sub>3</sub>, iron(III) chloride.]*
4. If iron dissolved in the stomach as slowly as it did in the beaker, would the iron in your breakfast cereal be beneficial to you? *[No, it would not be in an absorbable form.]*
5. Of what use is iron in the body? *[It is part of the heme molecule, which carries oxygen in the blood. The oxidation state of iron in the heme is +2.]*

#### Extensions

Read other labels on vitamins, etc. to determine the form of iron present. Iron is seldom eliminated from the body. Unless you have a disease such as anemia or lose blood, you probably do not need extra iron; however, pregnant and postpartum women may need supplements.

### Key Questions

1. Does food consist of chemicals? *[Yes.]*
2. How can a knowledge of chemistry help you decide what food to eat or buy? *[You can read and interpret the labels and not be fooled by false or ambiguous advertising.]*
3. An advertisement states that a prune, ounce for ounce, has more vitamins than a plum. Why is this statement misleading? *[Only water is removed from the plum to make a prune. The vitamins remain, but the mass is less. You get the same mass of vitamins from a prune as from a plum.]*
4. Are food additives bad? *[Not always; they can protect from spoilage and deficiency-diseases.]*

### GROUP AND DISCUSSION ACTIVITIES



## Counterintuitive Examples

1. Labels do not tell the whole story. There are many prepared foods that contain compounds that cannot be digested; drugs or cosmetics may contain compounds to which one is allergic; drugs or foods may contain nutrients in a form the body does not use.
2. Enriched flour vs. whole wheat flour. White flour is prepared by removing some of the bran and germ. White flour is bleached with benzoyl peroxide. Enriched flour has had nutrients added to it. The whole wheat flour is made from the whole grain. It may also have added nutrients. It does not last as long as white flour because the oil from the wheat germ becomes rancid, so preservatives are often added.
3. Refined white sugar vs. honey. White sugar is recrystallized sucrose, a chemical combination of glucose and fructose, extracted from sugar cane or sugar beets, usually by concentrating the syrup and letting the crystals form. The brown decomposition products of this process are removed in the refining. Brown sugar is white sugar to which molasses has been added. When sucrose is eaten, an enzyme in the body changes it to glucose and fructose. Honey is a solution of sugars produced by bees, a 50/50 mixture of glucose and fructose. In terms of sugar content, refined white sugar and honey are equivalent. Judgments regarding the choice of honey over refined sugar become matters of personal preference.
4. All food additives are harmful. Preservatives, such as sugar and salt, and antioxidants, such as lemon juice, have been used for thousands of years as additives. Additives can be very important in an urban society where food may be shipped long distances before being used. The safety of the additives is monitored by the FDA. However, some people may have a reaction to a specific additive, such as MSG (monosodium glutamate) and should read labels or inform food providers of the problem.
5. It is safe to eat fat or food containing cholesterol. Some fat and cholesterol are necessary for healthy body functions. The body even manufactures cholesterol for its use and uses it for the vital biological role of the formation of steroid hormones (sex hormones) and Vitamin D. If the body does not provide enough cholesterol, some must be eaten. Fats are a source of long term energy storage.

## Group Discussion

1. Compare expensive and inexpensive nutrients such as vitamins and  $\text{Ca}^{2+}$  supplements. Compare contents and quantity. What makes the difference in the price? Use the *Merck Index* or a *Physician's Desk Reference* to identify ingredients.
2. How does a microwave oven work? Why must you vent the food in a microwave oven? Microwaves are a form of electromagnetic energy, with a shorter wave length and higher frequency (more energy) than radio waves and longer wave length and shorter frequency than visible light. Microwaves are like radar emissions and are absorbed by water, but are reflected by metal; they pass through glass, paper, and plastic. When the energy is absorbed, primarily by the water in the food, the molecules begin to move rapidly and produce heat to cook the food. They do not cook "from the inside out," but if allowed to stand, the heat will be conducted inward, cooking as it travels. Because the steam produced from the liquid water in the food can become very hot when microwaved in a closed space, all food should be vented and care used before opening microwaved packages.

3. Read and interpret food labels. The ingredient present in the greatest concentration is first on the list. Answer the following questions:

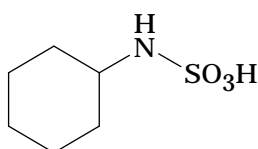
- How many cups of cereal will this package provide? [ $2/3 \times 15 = 10$  cups]
- How many calories are in one serving of the cereal? [85 cal]
- How many calories are *added* when you eat the cereal with  $1/2$  cup of whole milk? [75 cal]
- Does a serving of cereal plus milk provide more grams of protein, fat, or carbohydrate? [Carbohydrate]
- If you are 18 years old, you need 80% of the U.S. RDA for Vitamin C. How many servings of this cereal would you have to eat in order to meet your need for Vitamin C? [One serving provides 20%; to get 80%, one needs four servings.]
- If you ate two cups of this cereal, what percent of the U.S. RDA for niacin would be supplied by the cereal alone? [ $2/3$  cup provides 20%, and to get 2 cups, you need to eat three servings; hence,  $3 \times 20\% = 60\%$ .]
- How much more niacin would be supplied by 2 cups of this cereal plus milk? [ $2/3$  cup with milk provides 25%, and 2 cups would supply 75%; hence, 15% more.]
- What ingredients are found in the smallest and largest amount? [Vitamin B<sub>12</sub> and wheat bran, respectively.]
- What minerals are provided by this cereal? [Sodium, potassium, calcium, iron, phosphorus, magnesium, and copper]
- Which would provide less fat when used with this cereal: Vitamin D fortified or skim milk? [Skim milk contains less fat than whole milk.]
- What is the function of the BHA? [Food preservative]
- How is Vitamin C identified in the list of ingredients? [Sodium ascorbate]

<b>SUPER BRAN FLAKES</b>		
<u>Nutrition Information per Serving</u>		
Serving size:	1 oz (2/3 cup)	
Servings per container:	15	
	1 oz cereal	plus 1/2 cup Vitamin D fortified whole milk
Calories	85	160
Protein	3 g	7 g
Carbohydrate	20 g	25 g
Fat	0 g	4 g
Sodium	280 mg	350 mg
Potassium	200 mg	360 mg
Percentage of U.S. Recommended Daily Allowances (U.S. RDA)		
Protein	5	19
Vitamin A	<2	5
Vitamin C	20	20
Thiamine	20	20
Riboflavin	5	12
Niacin	20	25
Calcium	<2	20
Iron	20	20
Vitamin D	<2	10
Vitamin B <sub>6</sub>	20	20
Folic Acid	20	20
Vitamin B <sub>12</sub>	20	24
Phosphorus	18	26
Magnesium	10	13
Zinc	20	25
Copper	8	8
Pantothenic Acid	2	6
Ingredients: Wheat bran, milled yellow corn, sugar, malted cereal syrup, salt, sodium ascorbate, niacinamide, reduced iron, zinc oxide, BHA, pyridoxine hydrochloride (Vitamin B <sub>6</sub> ), thiamine mononitrate (Vitamin B <sub>1</sub> ), folic acid, Vitamin B <sub>12</sub> .		

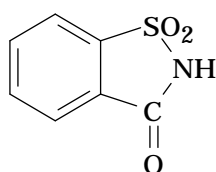


4. Discuss artificial sweeteners: saccharin, cyclamate, NutraSweet™ (aspartame) and Sweet One™ (acesulfame K).

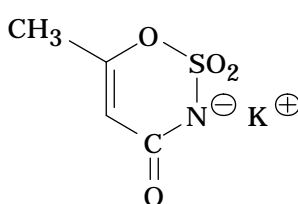
TABLE OF RELATIVE SWEETNESS	
Sweetener	Relative Sweetness (mass for mass)
Fructose	>1.0
Sucrose (cane sugar)	1.0
Cyclamate	30-80
Acesulfame K	150
Aspartame	100-200
Saccharin	500-700



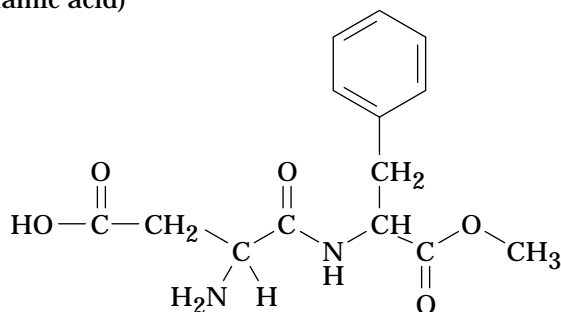
Cyclamate  
(Cyclamic acid)



Saccharin



Acesulfame K



Aspartame

- Which sweeteners are presently approved for use in the U.S.? *[All except cyclamate]*
- Which one is most used in soft drinks? *[Aspartame]*
- Which ones are destroyed by heat? *[Aspartame and saccharin]*
- Which ones are not destroyed by heat? *[Acesulfame K and cyclamate]*
- Which one is metabolized by the body? *[Aspartame]*

5. Discuss artificial fats, Simplese, Olestra.

Current medical information linking heart disease to saturated fats has prompted chemical manufacturers to develop artificial fats. Both Procter and Gamble and the NutraSweet™ Company have developed fat substitutes.

Simplese™, developed by chemists at NutraSweet™, is an all natural fat substitute made from milk protein. It contributes only 1-2 calories per gram versus 9 calories per gram for fat. Each Simplese particle consists of several million loosely packed protein molecules. Their round shape and uniform size allows the particles to roll easily over one another, creating the smoothness and richness normally associated with fat. Simplese has found uses in ice cream, yogurt, salad dressings, and sour cream. However, since it is a protein, it cannot be used in baked or fried foods.

Olestra™, developed by Procter and Gamble, is a fat replacement that can be used in frying, cooking, and baking, because it is made from fat. Conventional fats are esters of glycerol and three fatty acid chains. Olestra is composed of sucrose with 6 to 8 fatty acid chains, usually produced from soybean or corn oil. Because Olestra is a larger molecule than a fat molecule, it is not hydrolyzed by the body's digestive enzymes. Olestra will be used to substitute 35% of the fat in oils and shortenings used in the home and up to 75% of the fats used in restaurants for deep frying and in the commercial production of fried snack foods. Olestra may also, someday, be found in ice cream, yogurt, and salad dressings. Both companies will make literature on their products available to schools.

6. Discuss cholesterol and fats (saturated and unsaturated) and the relationships between these substances (see *Organic Chemistry* module).
7. Read labels on vitamins and determine whether prices reflect differences in content. Compare standard brands with generic brands and with those called "natural." Rose hips can be used as an example.
8. Using McDonald's publications, determine the contents of a fast food lunch (see *Appendix*).
9. Analyzing Foodstuffs for Food Additives (or Is That Stuff Really in My Food?)
10. **Student Activity**

Students should collect food labels for one week prior to starting this activity. Teacher leads discussion on the 11 categories of food additives (see *Appendix*).

- a. Distribute the labels in plastic baskets among pairs of students.
- b. Each pair should look at the ingredient section on the labels and find two additives for each of the 11 categories on the chart (see *Appendix*).
- c. As each pair of students finishes looking through a basketful of labels, it is passed to an adjacent group, and they receive a different basket. This should take about 30 min.
- d. On the board, construct a table like the one in the student handout, and ask students to fill in with the additives they found.

## Language of Chemistry

**carbohydrate** polyhydroxy aldehyde or ketone with a hydrogen/oxygen ratio of 2:1; all natural carbohydrates are produced by plants except glycogen.

**cholesterol** steroid found in animal cells; building block of many steroidal compounds, including many hormones.

**fat** triacylglyceryl ester formed by mainly saturated long chain fatty acids with glycerol; melting points of fats are generally above room temperature.

**fatty acid** long chain carboxylic acid that may be saturated or have varying degrees of unsaturation.

**glycerol** triol with the formula  $C_3H_8O_3$  that forms the "backbone" of fats and oils; since three fatty acid residues are bonded by ester linkages in fats and oils, these compounds are called triglycerides.

## TIPS FOR THE TEACHER



**lipid** group of fat-soluble compounds that includes fats, oils, waxes, phosphatides, cerebrosides, and terpenoids (of which steroids are a subclass).

**minerals, dietary** inorganic elements that play an essential role in certain body functions; some are present in fairly large quantities and some are present in trace amounts.

**oil** triacylglyceryl ester formed by mainly unsaturated long chain fatty acids with glycerol; melting points of oils are general below room temperature.

**protein** macromolecule composed principally of long chains of amino acids.

**saturated** term describing organic compounds with only carbon-carbon single bonds.

**unsaturated** term describing organic compounds with double and/or triple carbon-carbon bonds.

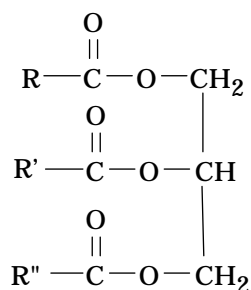
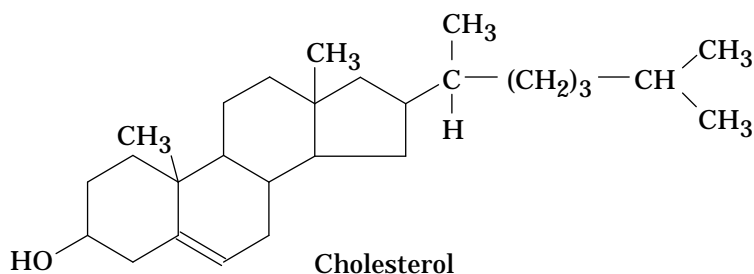
**vitamin** organic compound essential for the growth and survival of an organism but that the organism cannot synthesize for itself.

### Common Student Misconceptions

“Organic” foods are better than “processed” foods. Chemical compounds have the same formula wherever they are produced. Oyster shell calcium carbonate is the same as calcium carbonate precipitated in the laboratory.

### Other

1. **Cereal and additives** Check the labels for additions to your cereal. Check on the form of iron; “reduced iron” almost always means elemental iron; iron(III) salts precipitate in the intestine ( $\text{pH} = 10$ ) as  $\text{Fe}(\text{OH})_3$ ; iron(II) salts are stabilized as complexes (heme iron).
2. **Orange juice with calcium** Check on the form of calcium added. The acid in orange juice could dissolve any calcium carbonate, releasing  $\text{CO}_2$ , but other additives might not dissolve in the stomach acid. Is orange juice with added calcium a good buy? *[No; very expensive.]*
3. **New Horizons bread** This bread is advertised as having fewer calories and more fiber. It contains cellulose, which is not metabolized and, therefore, provides fewer calories. Cellulose is also not useful as fiber in humans. Some “light” breadstuffs, such as frozen pancakes, also have a large amount of cellulose.
4. **Eggs and cholesterol** Egg yolks, but not the whites, contain cholesterol. Egg substitutes are often made from the whites.
5. **Analysis of nutrition in hamburger and french fries** Although there is still a debate over the disadvantage of saturated fats and their relationship to hardening of the arteries and cholesterol, students should be aware of these studies. Current research indicates that mono-unsaturated fats may be better than polyunsaturated or saturated fats. We know that cholesterol is carried in the body by high density lipoproteins to the liver to be excreted and by low density lipoproteins through the blood stream. This knowledge has led to the erroneous nomenclature, “good” cholesterol (HDL) and “bad” cholesterol (LDL). Cholesterol has a different chemical formula and is a different compound from lipoproteins and triglycerides.



Triglyceride

R, R', R'' are fatty acid residues

(Lipoproteins are conjugates of lipid and protein)

See Transparency of McDonald food components and *ChemMatters* article (see *References*, Baugh, 1989).

6. **Sodas and yogurt** Notice the caffeine in colas and the presence of phosphoric acid. Notice the low pH of these compounds. Sodas are substitutes for commercial acids in automobile garages, *etc.* Notice how the Calories in yogurt depend upon the kind of milk (% fat) used in its production.
7. **Food additives, nitrites, nitrates, ascorbic acid or sorbates, dyes** There are several different types of food additives: (GRAS additives are "generally regarded as safe.".)
  - a. **Preservatives** To prevent spoilage and keep food fresh.
  - b. **Antioxidants** To keep fats from getting rancid.
  - c. **Coloring matter** To improve appearance (see *References*, McKone, 1990).
  - d. **Flavoring agents** Compounds, both natural and synthetic, to flavor and artificial sweeteners.
  - e. **Sweeteners**
  - f. **Sequestrants** To tie up metal ions that can cause decomposition of foods
  - g. **Gelling agents, stabilizers, and emulsifiers** To give foods a desired consistency.
  - h. **Acids and bases** To increase tartness or lower pH (*e.g.*, to inhibit crystallization) for acids. Bases are used in baking powder or to provide CO<sub>2</sub>.
8. Many foods such as peanuts, margarine, *etc.* carry a "no cholesterol" label. Are these foods more healthy than unlabeled "generic" peanuts and margarine? No. Only animal products contain cholesterol. Unless animal products have been added to foods like peanuts and margarine, any brand chosen will be cholesterol-free.



## HISTORY: ON THE HUMAN SIDE

### The Ethylene Glycol Tragedy that Triggered the Formation of the FDA

In the 1930's there were no laws in the United States that required drug manufacturers to test drugs before selling them to the public. However, in 1937, 107 people (mostly children) died after taking a liquid formulation of sulfanilamide. "Sulfa" was the first of the "wonder drugs," and a drug company had discovered that it dissolved well in ethylene glycol. Ethylene glycol, ordinarily used for antifreeze, has an appealing sweet taste, but it is extremely toxic. The public outrage was so great that Congress passed the 1938 Food, Drug and Cosmetic Act, which required that drugs be cleared for safety *before* they are put on sale in the marketplace. The young researcher, who discovered that it was ethylene glycol that killed the victims, was the same person, who in the 1960's, stopped thalidomide from being sold in the United States, Dr. Frances Kelsey.

## HUMOR: ON THE FUN SIDE

### 1. A chemical code

For " $\text{AsO}_4^{3-} \text{C}_6\text{H}_{12}\text{O}_6$ " read, "Our son ate glucose."

*CHEM 13 NEWS, September 1979, p. 11*

### 2. Word Search (see Appendix for master copy)

A D C A M X N A C E E X O E O Q Q  
F F G Z F A T S F T D U Y I Z A N  
R L L A R U R P U F I N P L R M T  
I O M U I C L A C X R U V B W M U  
K R K S Z F W R P F E S O G T O V  
M E C J D S J T E Q C H O K W L W  
Y T N N L W P A D T Y P E C Q A I  
T S X I N Z R M F D L M J M Z S B  
T E Q F M J N E R U G W H L E S M  
A L D U M A R A A S I F M O V E H  
L O T K R U X K I W R I B P J S N  
O H D A U E S I K V T P G X W V O  
T C Z U F G A B V B N I E T O R P

Words about the concepts in this module can be obtained from the clues given. Find these words in the block of letters:

1. Polyhydroxy aldehyde or ketone.
2. Peptide with more than 100 amino acid residues.
3. Lipids that exist as solids at room temperature.
4. Iron containing prosthetic group in hemoglobin and the cytochromes.
5. Nutrasweet™ is the commercial name of this substance.
6. Metal ion integral in neurotransmission, intracellular communication, and development of bone structure.
7. One example of a steroid compound.
8. Ester in which all three hydroxy groups on glycerol have been esterified by saturated or unsaturated fatty acids.



9. Member of a group of organic compounds essential in the diet in small amounts.
10. Additive that makes white sugar into brown sugar.

Answers: 1. CARBOHYDRATE 2. PROTEIN 3. FATS 4. HEME 5. ASPARTAME  
6. CALCIUM 7. CHOLESTEROL 8. TRIGLYCERIDE 9. VITAMIN  
10. MOLASSES

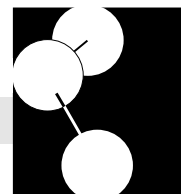
3. See cartoons at end of module.

1. Nutrition, by MECC (Minnesota Educational Computer Consortium, St. Paul, MN 55165)—Computer program that takes a day's meals and calculates calories, fat, protein, carbohydrate, vitamins, and minerals. The program also gives suggestions for altering your diet.
2. TVO Video (TV Ontario) cassette. *Organic Chemistry 2: Industrial Applications* has programs on soaps and detergents, cosmetics, glues, and fibers. Other cassettes: *From Rags to Britches* (artificial fibers); *Is it Soup Yet?* (cooking); *Hair: the Untold Story*; and *You are What You Eat*, TV Ontario Video, 143 West Franklin Street, Suite 206, Chapel Hill, NC 27516; (800) 331-9566.
3. Software published by Project SERAPHIM, Department of Chemistry, University of Wisconsin-Madison, 1101 University Avenue. Madison, WI 53706-1396: (608) 263-2837 (voice) or (608) 262-0381 (FAX).

For the Apple II computer: AP 1522

## MEDIA

# Links/Connections



**WITHIN  
CHEMISTRY**

- Biochemistry and Metabolism
- Analytical Chemistry
- Oxidation-Reduction
- Chromatography
- Solubility
- Synthetic Chemistry

**Lipids** Approximately 35-40% of the total calories taken by an average adult comes in the form of dietary lipids. Oxidation of lipids is well studied by chemists because this reaction is related to lipid deterioration and production of undesirable breakdown products. Crystalline properties of fats are important in formulations of ice creams, margarines, mayonnaise, and many other common food products. Hydrogenation of lipids is important in the food industry because degree of unsaturation is directly proportional to rate of oxidation. A study of emulsification of fats leads to studies in numerous areas of chemistry: crystal polymorphism, surface tension, van der Waals attraction, electrostatic repulsion, electric double layers, adsorption at interfaces, liquid crystals, complex formation.

**Proteins** The basic chemistry of proteins is always related to their functionality. For example, the chemistry of muscle contraction is related to rigor mortis and postmortem tenderness of meat. The unfolding and refolding of the helical chains in collagen help explain formation of gelatins. Chemical changes in proteins during food storage and processing can lead to unwanted breakdown products, with consequent alteration of nutritional quality.

**Carbohydrates—Monosaccharides and Oligosaccharides** The many flavor compounds in foods are the results of the degradation and subsequent rearrangements and reactions of monosaccharides and oligosaccharides. The reaction mechanisms of these reactions have been extensively studied. Polysaccharides are important in food chemistry because of their unique gelling characteristics. Gelling of polysaccharides often requires complexation with metal ions, and the degree and nature of the substituent groups also plays an important role.

**Vitamins and Minerals** Vitamins are essential for the proper functioning of the body. They cannot be biosynthesized by human beings and therefore must be part of the diet. About a dozen different vitamins have been identified, two-thirds of which are water-soluble and one-third of which are fat-soluble. The water-soluble vitamins wash out through the action of the body's aqueous disposal system, and thus must be included in the daily diet. On the other hand, the fat-soluble vitamins can be stored in the adipose tissues and can leach into the blood stream as needed. In fact, the fat-soluble vitamins tend to accumulate, sometimes to toxically high levels if ingested in excess. Essential minerals can be divided for convenience into macrominerals (Ca, Cl, Mg, Na, K, P and S) and trace minerals (Cr., Co, Cu, F, I, Fe, Mn, Mo, Ni, Se and Zn). All are essential in the diet and lead to deficiency conditions if lacking or in short supply in the diet. *ChemCom* (2nd ed.) provides an excellent section on vitamins and

minerals, including a Vitamin C laboratory activity. See *ChemCom* (1993) in the *References*. (Idea contributed by Angie Matamoros.)

**Kitchen Chemistry** Kneading dough is a chemical reaction. During kneading and subsequent resting periods, disulfide bonds in the wheat protein, which is 80% gluten, undergo reduction and subsequent reoxidation. The initiation of reduction in dough-mixing is thought to be due to thiol-disulfide exchange and possible formation of free radicals. Disulfide reduction physically loosens the gluten and facilitates better interaction with the starch, lipids and other additives to form a continuous network complex.

**Fertilizers** Because of fertilizer losses in the field, energy requirements and environmental concerns, alternative sources of ammonia are being explored. Technology is being developed to make more efficient use of fertilizers, particularly nitrogen fertilizers to control nitrification so that nutrients can be made available to plants on a need-supply schedule (see *Industrial Inorganic Chemistry* module).

Medicine

Nutrition

Advertising

Business

Chemical industry

Food Science

Home Economics

## BETWEEN CHEMISTRY AND OTHER DISCIPLINES

**Biology** To meet the world's nitrogen requirements, biologists are attempting to exploit nitrogen-fixing bacteria and blue-green algae that live in fields, forests, and oceans.

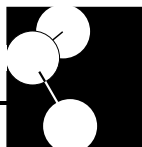
**Animal Production** Chemists can make a major contribution to animal production by developing (a) new sources of nonprotein nitrogen that are effective, safe, and inexpensive to use in the diets of forage animals, and (b) acceptable growth stimulants for use in animal feeds.

**Fish Production** Research can be expanded to improve fish feeds, control fish diseases, and develop sex-controlling chemicals. Aquaculture technology in the tropics and subtropics can help alleviate food shortages—fish are extremely efficient converters of feed into proteins. There are many opportunities for chemists to contribute to fish production research.

Chemists can contribute in the following areas of food processing and production:

**Food additives** Additives facilitate processing, handling, distribution, and preparation of foods in the home; they control chemical, physical, and biological changes; they extend shelf life of foods; and they improve sensory and nutritive properties. Without additives, there would be few convenience foods, and certain fresh fruits and vegetables would not be available year round. The search for effective additives from natural sources is the domain of the natural products chemist.

**Food processing and preservation** Nitrites have, in the past, been added to smoked and cured meats to improve color and to inhibit the growth of the toxic botulism organism. Nitrite additives are no longer acceptable because under



certain conditions of heating and storage, they react with other constituents of the food to produce minute quantities of nitrosamine, which is carcinogenic in rats. Chemists are engaged in a research program to determine the mechanism by which nitrites inhibit botulism, and with this information, to develop safe alternative preservatives.

**Development of unconventional sources of food and feed** In modern times, various attempts have been made to use microbial cell mass, sometimes called SCP (single-cell protein) as a major protein source. Research chemists have found ways to couple certain carbon source substrates, such as methanol, methane, and wood hydrolyzate, with the appropriate microorganisms to produce SCPs for a variety of uses. Presently, major constraints in the widespread use of SCPs are economics (production costs are considerable and vary with the raw material), medical problems (nucleic acids in yeast have been found to increase blood uric acid levels, leading to an increase of gout), and nutritional limitations (high nucleic acid levels and low levels of two essential amino acids, methionine, and tryptophan).

**Psychology** Relationship of eating disorders to nutritional needs.

## **TO THE CONTEMPORARY WORLD**

### **Personal**

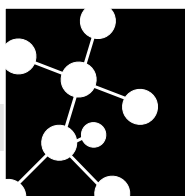
- Informed consumerism
- Analysis of diet
- Knowing the best foods to eat
- Assessment of advertising

### **Community**

1. **Field trips** fish hatchery, local food processing plant, dairy, sewage treatment plant
2. **Knowledgeable individuals** nutritionist, dietitian

### **Societal**

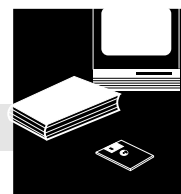
1. Making decisions on food safety. Library research on key considerations regarding the food supply. Criteria include scientific evidence, social value, economic impact, the decision structure and political acceptability.
2. Evaluating benefits and risks under the law. What are "safe" levels for food additives? Should persistent pesticides (such as DDT) be replaced with more toxic, but less persistent ones? Has the replacement of trichloroethylene with methylene chloride as an extracting solvent resulted in enhancement of human health?
3. Life-style, eating, and health care. The relationship between diet and disease.
4. Nutritional risk and life expectancy: hunger and malnutrition. Worldwide hunger problem. When to intervene? Political, ethical, economic, scientific, medical aspects.
5. Dietary assessment: Food ecology—nature, nurture, and nurture.
6. What is food and what is poison?



## Extensions

Any one of the topics listed under Links and Connections would make a suitable research paper for a group or individual for honors projects, and with suitable guidance, for a laboratory research project (or an interdisciplinary research project). The topic of *Food and Chemistry* cuts across virtually every aspect of human endeavor. It is a rich area to explore on many levels.

# References



Module drafted by Jennifer Hubert, Jane A. Miller and Marie C. Sherman, the Missouri team.

Agricultural Research Service. (1979). *Composition of foods*. U.S. Department of Agriculture.

Resource for *Activity 1: Analysis of Salt in Snack Food*.

American Chemical Society. *ChemCom (Chemistry in the Community)*, 2nd ed. (1993). Dubuque: Kendall/Hunt Pub. Co.

Chemistry text developed by the American Chemical Society that links study of chemistry with contemporary societal issues.

American Public Health Association. (1965). *Standard methods for the examination of water and wastewater*. New York: American Public Health Association.

Resource for *Activity 1: Analysis of Salt in Snack Food*. Address: American Public Health Association, 1740 Broadway, New York, NY, 10019.

Bergandine, D.R., Jones, L. and Frederick, B. (1991, March). The chemistry of fitness. *The Science Teacher*, 29-32.

Blumenthal, D. (1990, May). Red no. 3 and other colorful controversies. *FDA Consumer*, 24(4), 18-21.

Resource for *Activity 2: Chromatographic Comparison of M&M™ Candy with Reese's Pieces™*.

Bodanis, D. (1986). *The secret house*. New York, NY: Simon and Schuster.

Committee on Chemistry and Public Affairs. (1980). *Chemistry and the food system*. Washington, DC: American Chemical Society.

Report generated to enhance public understanding of the food system from farm to table. The report describes how chemical substances have provided benefits in production, storage and processing of foods; it also includes some of the disadvantages, problems and risks involved.

Damon, G. E., and Javssen, W. F. (1973, July-August). Additives for eye appeal. *FDA Consumer*, 7(6), 15-18.

Resource for *Activity 2: Chromatographic Comparison of M&M™ Candy with Reese's Pieces™*.

Eckstein, E. F. (1980). *Food, people, and nutrition*. Westport, CT: AVI Publishing Co.

Unique nutrition textbook that includes approaches to nutrition on the whole body level, the cellular level, and the life cycle level. Questions regarding malnutrition in a land of plenty raise societal issues that would make interesting research problems and discussion topics.

Florman, M., and Florman, M. (1990). *Fast foods eating in and eating out*. Yonkers, NY: Consumers Union.

Friedstein, H. G. (1983). Basic concepts of culinary chemistry. *Journal of Chemical Education*, 60, 1037.

Hillman, H. (1989). *Kitchen science*. Boston, MA: Houghton Mifflin.

Compendium of information for cooks written in a catechism question-and-answer style. Questions range all the way from the best way to kill a lobster to causes of discoloration of foods. Some chemical names, but no formulas.

Korchin, F. G. (1983). *Science in the marketplace*. Red Bank, NJ: Tiger Publications.

Order from Tiger Publications, 32 Friendship Ct., Red Bank, NJ 07701.

Markow, P. G. (1988). Ideal solvent for paper chromatography of food dyes. *Journal of Chemical Education*, 65, 899-900.

Piscatella, J. C. (1987). *Don't eat your heart out cookbook*. New York, NY: Workman.

A resource for *Activity 1: Analysis of Salt in Snack Food*. (Publisher's address: Workman Publishing, 708 Broadway, New York, NY 10003.)

Selinger, B. (1989). *Chemistry in the marketplace*. New York, NY: Harcourt Brace Jovanovich.

Tocci, S. (1987). *Chemistry around you*. New York, NY: Prentice Hall.

Wong, D. W. S. (1989). *Mechanism and theory in food chemistry*. New York, NY: Van Nostrand Reinhold.

Reference work that focuses on the reaction mechanisms and theories essential to understanding the many chemical processes that occur in foods and food systems. The emphasis is on the interactions among food constituents that correlate with the chemistry of individual food systems.

There are many articles concerning household chemistry in *ChemMatters*, *Journal of Chemical Education*, *FDA Consumer*, and *Chemical and Engineering News*. These are a few examples of these articles.

Baugh, M. (1989). Oil changes. *ChemMatters*, 7(4), 7-9.

Benson, K. D. (1990). Fast fat. *ChemMatters*, 8(1), 13-15.

Blumenthal, D. (1990). Red dye no. 3 and other colorful controversies. *FDA Consumer*, 24(4), 18-21.

Emsley, J. (1988). Artificial sweeteners. *ChemMatters*, 6(1), 4-8.

Farley, D. (1990). Keeping up with the microwave revolution. *FDA Consumer*, 24(2), 17-21.

Glover, D. (1990). The margarine puzzle. *ChemMatters*, 8(3), 16.

Marmion, D. M. (1979). *Handbook of U.S. colorants for foods, drugs, and cosmetics* (pp. 53-93). New York, NY: John Wiley.

McCamish, M. (1987). The rise of self-rising flour. *Journal of Chemical Education* 64, 710-12.

MeKone, H. G. (1990, October). Copper in the candy, chromium in the custard. *Today's Chemist*, 3(5), 22-25, 34.

Pomeranz, Y., Finney, K. F., and Hoseney, R. C. (1978). Molecular approach to breadmaking. *Science*, 167, 944-949.

Stehlin, D. (1991). Women and nutrition. *FDA Consumer*, 25 (1), 11-13.

### **Artificial Fat Information**

Olestra Professional and Technical Relations, 2 Procter and Gamble Plaza, Cincinnati, OH 45202.

The NutraSweet Company Consumer Affairs Center, Box 830 Deerfield, IL 60015  
1-800-321-7254 (9A.M.-3P.M. CST).



## **Nutritional Analysis**

Important Nutritional Information About McDonald's® Menu. Pamphlet No. 9. (1990). McDonald's Nutrition Information Center, McDonald's Corporation, Oak Brook, IL 6052. (708) 575-FOOD.

U.S. Department of Agriculture Food Pyramid. Contact Regional Office, Food and Nutrition Service, U.S. Department of Agriculture (in local telephone book) for a copy. The Food Pyramid was publicized in the summer of 1992. It replaces the previous five suggested food groups as suggestions for healthy eating.

Regional Offices, U.S. Department of Agriculture Food and Nutrition Service

Mid-Atlantic Regional Office  
Mercer Corporate Park  
CN 02150, Trenton, NJ 08650  
(609) 259-5146; (609) 348-5146

Midwest Regional Office  
50 East Washington Street  
Chicago, IL 60602  
(312) 886-5307

Mountain Plains Regional Office  
2420 West 26th Avenue, Suite 430-D  
Denver, CO 80211  
(303) 964-0330

Northeast Regional Office  
33 North Avenue  
Burlington, MA 01803  
(508) 272-8833; (508) 223-0280

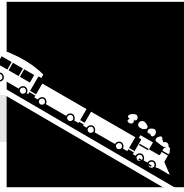
Southeast Regional Office  
1100 Spring Street, NW  
Atlanta, GA 30309  
(404) 881-4028

Southwest Regional Office  
1100 Commerce Street  
Dallas, TX 75242  
(214) 729-0204

Western Regional Office  
550 Kearney Street, Room 400  
San Francisco, CA 94108  
(415) 556-4939

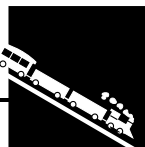
The National Dairy Council provides informational films and materials on request. To access the unit nearest you, contact the National Dairy Council, 6300 North River Road, Rosemont, IL 60018-4233; (312) 696-1860, ext. 220.





# Appendix

- **Transparency Masters**
  1. McDonald's Nutritional Analysis I  
McDonald's Nutritional Analysis II
  2. Food Additives and Examples
  3. Analyzing Foodstuffs for Food Additives
  4. Word Search
- **Humor**



## McDonald's Nutritional Analysis I

### USRDA (U.S. Recommended Daily Allowance)

#### Sandwiches *Nutrition Information per Serving*

Item	Hamburger		Cheeseburger		Quarter Pounder®		Quarter Pounder® w/cheese®		Big Mac®		Filet-O-Fish®		McD.L.T.®		McChicken®	
	Amount	%USRDA	Amount	%USRDA	Amount	%USRDA	Amount	%USRDA	Amount	%USRDA	Amount	%USRDA	Amount	%USRDA	Amount	%USRDA
Serving Size (g)	102		116		166		194		215		142		234		190	
Calories	260		310		410		520		560		440		580		490	
Protein (g)	12.3	20	15	25	23.1	35	28.5	45	25.2	40	13.8	20	26.3	40	19.2	45
Carbohydrate (g)	30.6		31.2		34		35.1		42.5		37.9		36		39.8	
Fat (g)	9.5		13.8		20.7		29.2		32.4		26.1		36.8		28.6	
Mono-unsaturated fatty acids (g)	5.09		7.66		11.38		16.51		20.90		10.22		16.7		11.5	
Poly-unsaturated fatty acids (g)	0.77		0.93		1.21		1.51		1.50		10.76		8.5		11.6	
Saturated fatty acids (g)	3.63		5.17		8.09		11.18		10.05		5.16		11.5		5.4	
Cholesterol (mg)	37		53		86		118		103		50		109		42.6	
Sodium (mg)	500		750		660		1150		950		1030		990		780	
Vitamin A Activity (IU)	152	4	392	8	223	4	703	15	352	8	146	2	754	15	104	2
Vitamin C (mg)	2.15	4	2.15	4	3.24	6	3.24	6	1.68	2	0.06		7.38	10	2.42	4
Thiamin (mg)	0.28	20	0.29	20	0.36	25	0.37	25	0.48	30	0.30	20	0.39	25	0.96	60
Riboflavin (mg)	0.16	10	0.21	15	0.29	15	0.39	20	0.41	25	0.15	8	0.36	20	0.21	15
Niacin (mg)	3.84	20	3.86	20	6.70	35	6.73	35	6.81	35	2.68	15	6.87	35	8.92	45
Calcium (mg)	121.65	10	198.51	20	141.74	15	295.46	30	255.95	25	164.84	15	225.30	25	142.62	15
Iron (mg)	2.29	15	2.3	15	3.68	20	3.72	20	4	20	1.83	10	3.91	20	2.61	15

#### Soft Drinks *with ice*

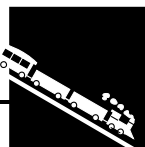
	Coca-Cola Classic®				Orange Drink				Sprite®				Diet Coke®			
	12 Fl Oz	16 Fl Oz	22 Fl Oz	32 Fl Oz	12 Fl Oz	16 Fl Oz	22 Fl Oz	32 Fl Oz	12 Fl Oz	16 Fl Oz	22 Fl Oz	32 Fl Oz	12 Fl Oz	16 Fl Oz	22 Fl Oz	32 Fl Oz
Carbohydrate (g)	38	50	70	101	33	44	60	88	36	48	66	96	0.3	0.4	0.5	0.6
Calories	140	190	260	380	130	180	240	360	140	190	260	380	1	1	2	3
Sodium (mg)	15	20	25	40	10	20	20	25	15	20	25	40	30	40	60	80

## McDonald's Nutritional Analysis II

### Other Items Nutrition Information per Serving

Item	Small French Fries		Medium French Fries		Large French Fries		Apple Pie		Vanilla Lowfat Milk Shake		Chocolate Lowfat Milk Shake		Strawberry Lowfat Milk Shake	
	Amount	%USRDA	Amount	%USRDA	Amount	%USRDA	Amount	%USRDA	Amount	%USRDA	Amount	%USRDA	Amount	%USRDA
Serving Size (g)	68		97		122		83		293		293		293	
Calories	220		320		400		260		290		320		320	
Protein (g)	3.13	4	4.44	6	5.61	8	2.2	4	10.8	15	11.6	20	10.7	15
Carbohydrate (g)	25.6		36.3		45.9		30		60		66		67	
Fat (g)	12		17.1		21.6		14.8		1.3		1.7		1.3	
Mono-unsaturated fatty acids( g)	6.49		9.21		11.64		9.11		.67		.92		.64	
Poly-unsaturated fatty acids (g)	0.50		0.70		0.89		0.87		.05		.05		.05	
Saturated fatty acids (g)	5.05		7.17		9.06		4.83		.63		.76		.63	
Cholesterol (mg)	9		12		16		6		10		10		10	
Sodium (mg)	110		150		200		240		170		240		170	
Vitamin A Activity (IU)	0		0		0		0		306	6	306	6	306	6
Vitamin C (mg)	8.16	15	11.64	20	14.64	25	11.40	20	0		0		0	
Thiamin (mg)	0.14	10	0.19	15	0.24	15	0.06	4	0.13	8	0.13	8	0.13	8
Riboflavin (mg)	0		0		0		0.02		0.48	30	0.50	30	0.48	30
Niacin (mg)	1.84	10	2.60	15	3.29	15	0.32		0.31		0.40	2	0.31	2
Calcium (mg)	9.93		14.10		17.81		10.65		327.24	35	332.48	35	327.31	35
Iron (mg)	0.52	2	0.73	4	0.93	6	0.71	4	0.10		0.84		0.09	

Item	Lowfat Frozen Yogurt Cone		Strawberry Lowfat Frozen Yogurt Sundae		Hot Fudge Lowfat Frozen Yogurt Sundae		Hot Caramel Lowfat Frozen Yogurt Sundae		McDonaldland Cookies		Chocolaty Chip Cookies	
	Amount	%USRDA	Amount	%USRDA	Amount	%USRDA	Amount	%USRDA	Amount	%USRDA	Amount	%USRDA
Serving Size (g)	86		171		169		174		56		56	
Calories	100		210		240		270		290		330	
Protein (g)	4	6	5.7	8	7.3	10	6.6	10	4.2	6	4.2	6
Carbohydrate (g)	22		49.2		50.5		59.3		47.1		41.9	
Fat (g)	0.75		1.1		3.2		2.80		9.2		15.6	
Mono-unsaturated fatty acids( g)	0.28		0.39		0.76		1.22		6.80		10.17	
Poly-unsaturated fatty acids (g)	0.06		0.04		0.05		0.09		0.52		0.39	
Saturated fatty acids (g)	0.41		0.63		2.35		1.51		1.85		5.04	
Cholesterol (mg)	3		5		6		13		0		4	
Sodium (mg)	80		95		170		180		300		280	
Vitamin A Activity (IU)	128	2	214	4	214	4	291	6	0		0	
Vitamin C (mg)	0		1.3	2	0		0		0		0	
Thiamin (mg)	0.04	2	0.07	4	0.08	6	0.08	6	0.25	15	0.18	10
Riboflavin (mg)	0.18	10	0.29	20	0.35	20	0.35	20	0.18	10	0.21	10
Niacin (mg)	0.37	2	0.25		0.30		0.26		2.54	10	2.47	10
Calcium (mg)	112	10	190.46	20	235.13	25	221.77	20	8.91		23.92	2
Iron (mg)	0.23		0.16		0.48	2	0.08		2.07	10	2.18	10



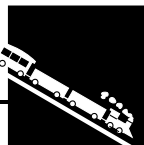
## Food Additives and Examples

Additive Type	Purpose	Examples
Nutrient	Improve nutritive value	Vitamins and minerals; iodine in iodized salt, B vitamins in enriched flour
Flavoring agents	Add or enhance flavor	Salt, monosodium glutamate (MSG), spices
Preservatives, antimycotic agents (growth inhibitors)	Prevent spoilage, microbial growth	Propionic acid, sorbic acid, benzoic acid, and salt retard mold growth on cheese, bread; sodium nitrite in meats adds to flavor, maintains pink color, and prevents growth of <i>Clostridium botulinum</i>
Antioxidants	Prevent fat rancidity	BHA and BHT react with free radicals to prevent oxidation of unsaturated fats
Coloring agents	Increase visual appeal	Carotene—natural yellow color added to butter and margarine, converted to vitamin A in the body; synthetic dyes
Leavening agents	Make foods light in texture	Baking powder and baking soda produce CO <sub>2</sub> that expands food as it cooks
Bleaches	Whiten foods such as flour and cheese; hasten maturing of cheese	SO <sub>2</sub> bleaches, disinfects, and preserves dried foods; seems safe in foods except for persons allergic to it
Emulsifiers	Give texture, smoothness, other desired consistencies; stabilize oil-water mixtures	Cellulose gums, dextrins in whipped cream, cake mixes, mayonnaise
Anticaking agents	Keep foods free flowing	Sodium ferrocyanide added to salt to prevent caking
Humectants	Retain moisture	Glycerin
Sweeteners	Impart sweet taste	Sugar (sucrose), dextrin, fructose, saccharin, aspartame, sorbitol, mannitol

### Analyzing Foodstuffs for Food Additives (or is that stuff really in my food?)

**DIRECTIONS** While looking at the ingredients section of food labels, find two examples for each of the 11 categories of food additives shown below. You may use the same label for more than one category. If the label lists the specific name of the additive, write the name underneath the product name.

	Example 1	Example 2
Nutrients		
Flavoring agents		
Preservatives		
Antioxidants		
Coloring agents		
Leavening agents		
Bleaches		
Emulsifiers		
Anticaking agents		
Humectants		
Sweeteners		

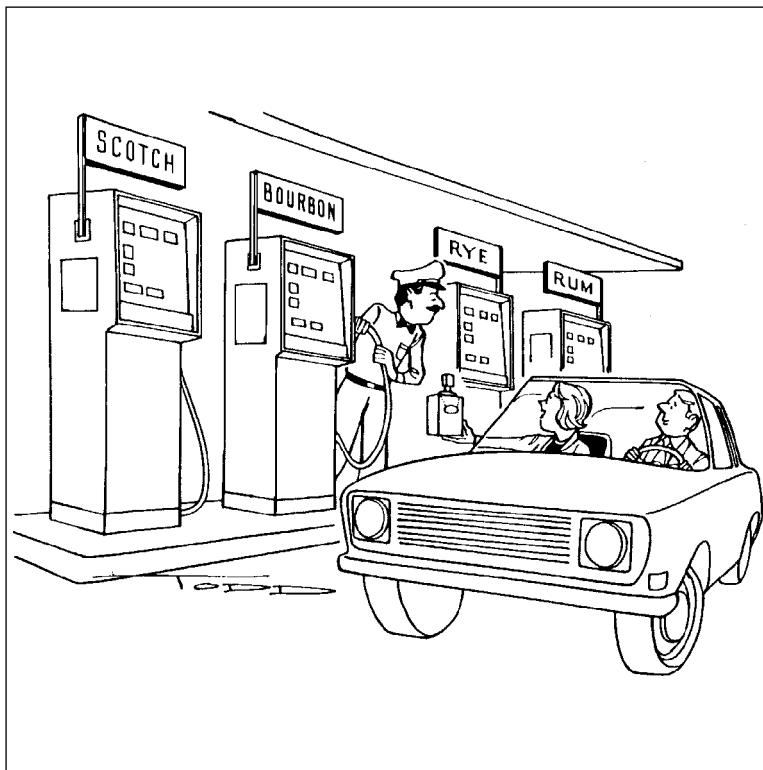


## Word Search

A D C A M X N A C E E X O E O Q C  
F F G Z F A T S F T D U Y I Z A N  
R L L A R U R P U F I N P L R M T  
I O M U I C L A C X R U V B W M U  
K R K S Z F W R P F E S O G T O V  
M E C J D S J T E Q C H O K W L W  
Y T N N L W P A D T Y P E C Q A I  
T S X I N Z R M F D L M J M Z S B  
T E Q F M J N E R U G W H L E S M  
A L D U M A R A A S I F M O V E H  
L O T K R U T K I W R I B P J S N  
O H D A U E S I K V T P G X W V O  
T C Z U F G A B V B N I E T O R P

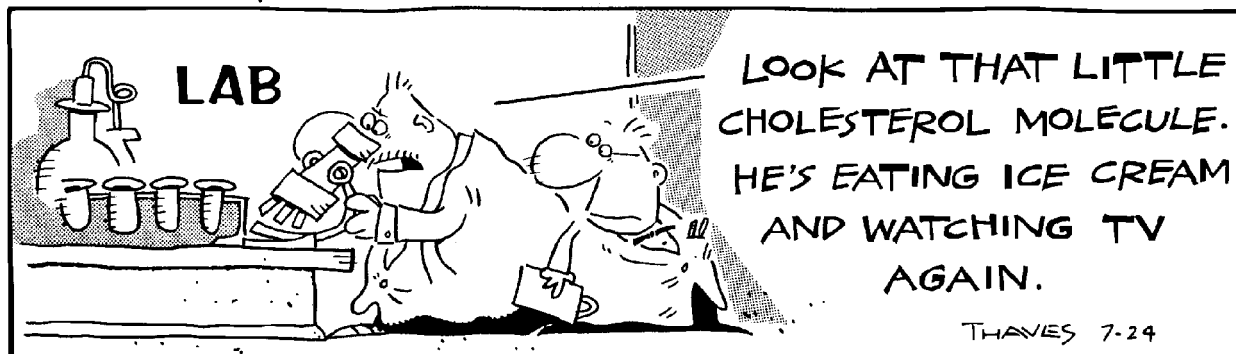
Words about the concepts in this module can be obtained from the clues given.  
Find these words in the block of letters:

1. Polyhydroxy aldehyde or ketone.
2. Peptide with more than 100 amino acid residues.
3. Lipids that exist as solids at room temperature.
4. Iron containing prosthetic group in hemoglobin and the cytochromes.
5. Nutrasweet™ is the commercial name of this substance.
6. Metal ion integral in neurotransmission, intracellular communication, and development of bone structure.
7. One example of a steroid compound.
8. Ester in which all three hydroxy groups on glycerol have been esterified by saturated or unsaturated fatty acids.
9. Member of a group of organic compounds essential in the diet in small amounts.
10. Additive that makes white sugar into brown sugar.

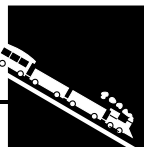


CHEMTECH, April 1980, p. 237. © American Chemical Society.  
Reprinted with permission.

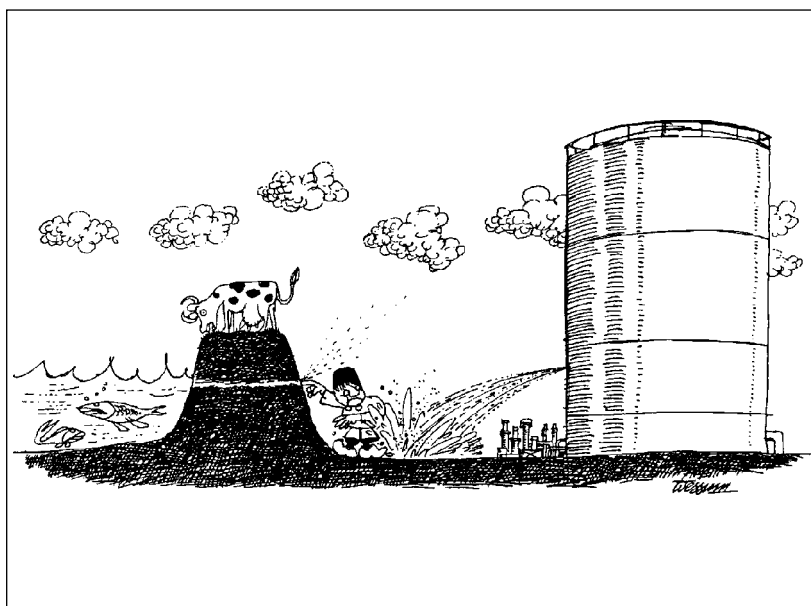
FRANK AND ERNEST ©by Bob Thaves



Reprinted by permission of NEA, Inc.

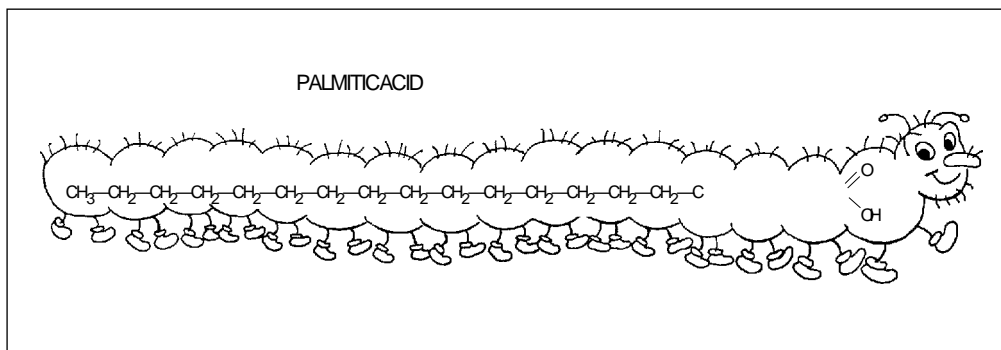


CHEMTECH, September 1980, p. 538. © American Chemical Society.  
Reprinted with permission.

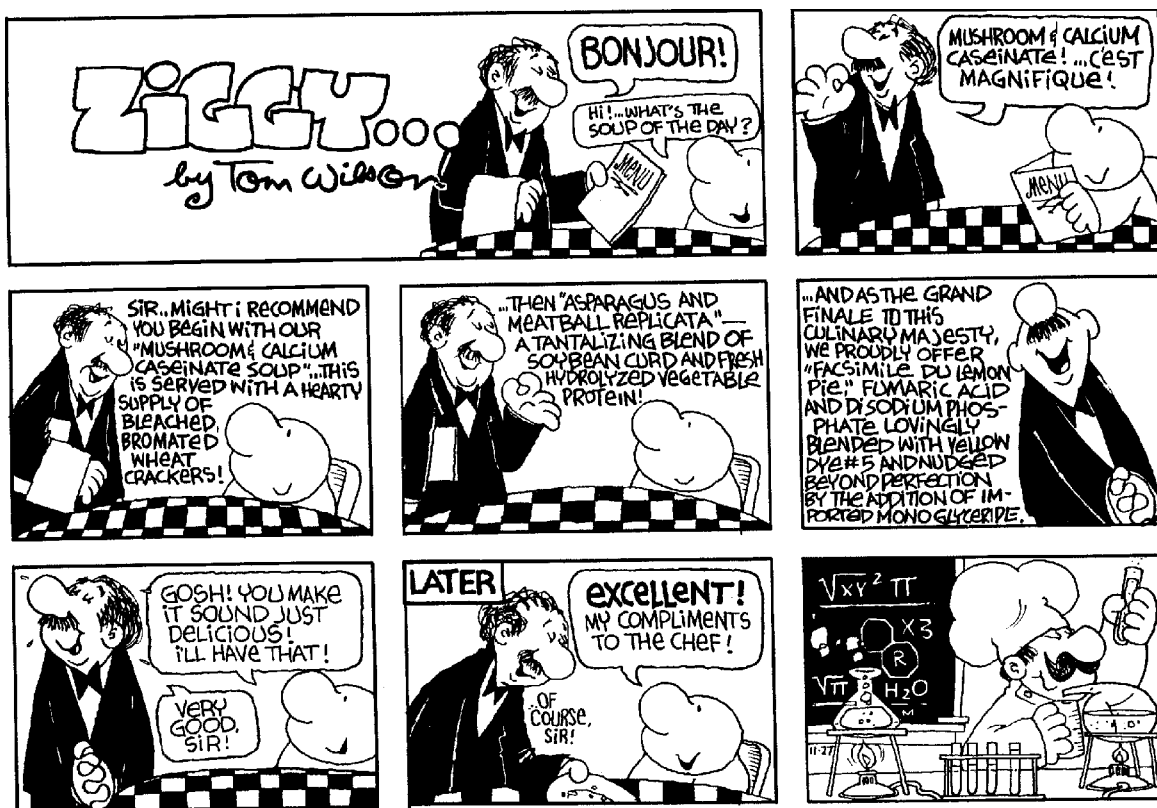


CHEMTECH, November 1972, p. 642. © American Chemical Society.  
Reprinted with permission.

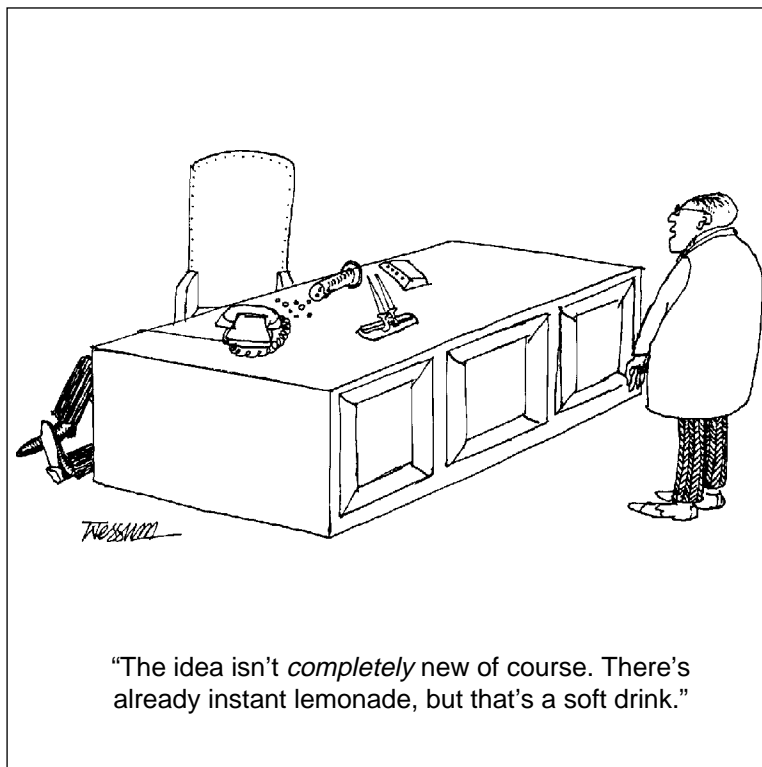
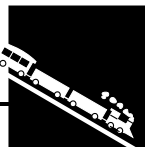




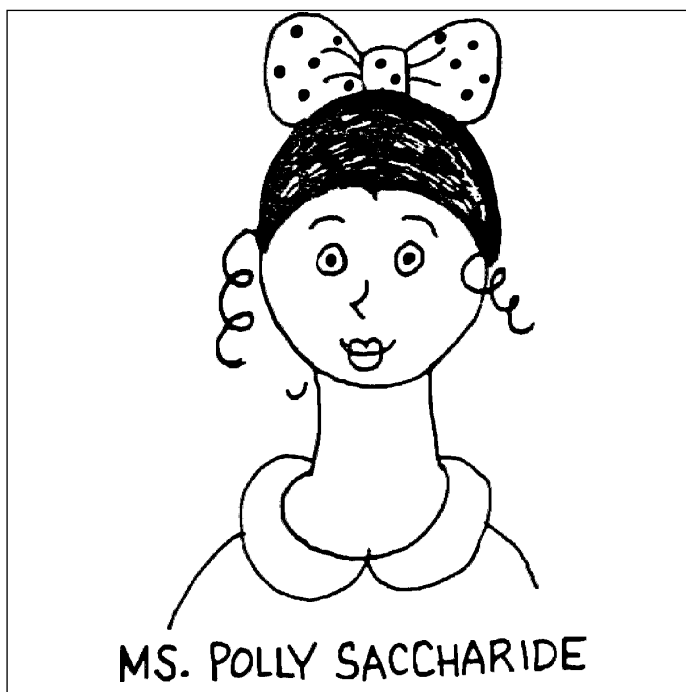
Used by permission of Veritex Publishing Co.



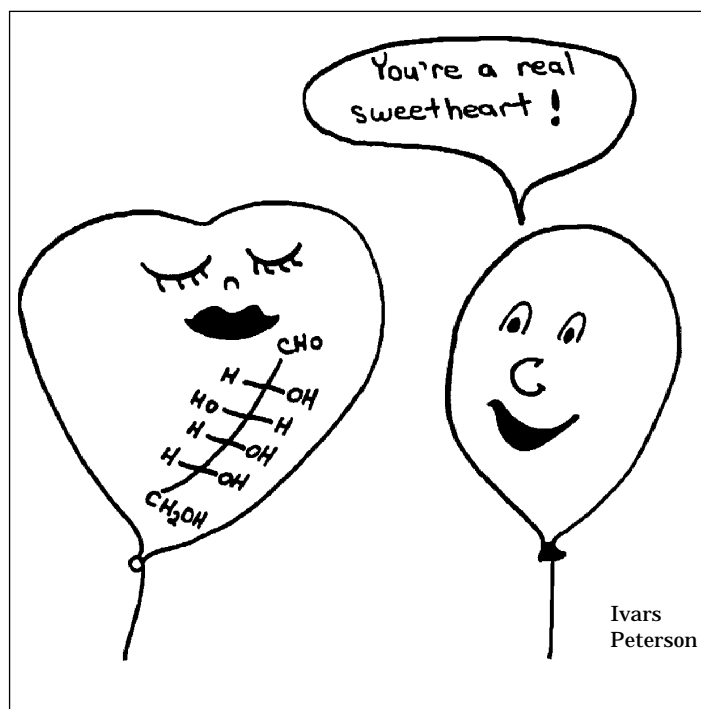
© 1988 Universal Press Syndicate. Reprinted with permission.



CHEMTECH, March 1974, p. 168. © American Chemical Society.  
Reprinted with permission.



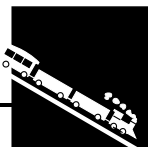
Used by permission of Veritex Publishing Co.



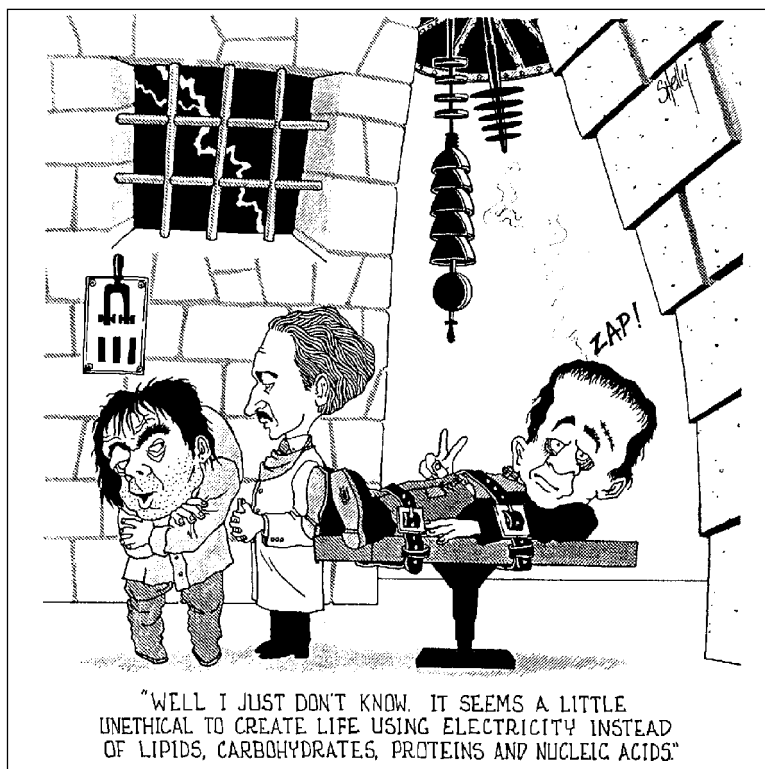
CHEM 13 NEWS, January 1983, p. 2. Reprinted with permission.



© 1993 by Sidney Harris. Reprinted with permission.



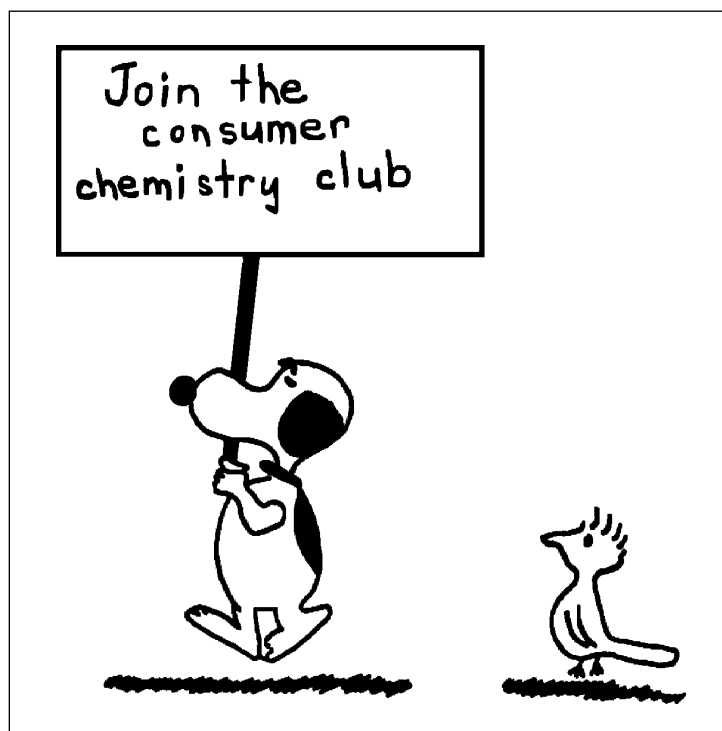
© 1993 by Sidney Harris. Reprinted with permission.



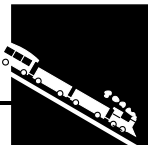
Cartoon by Shelly Fischman. Reprinted with permission.



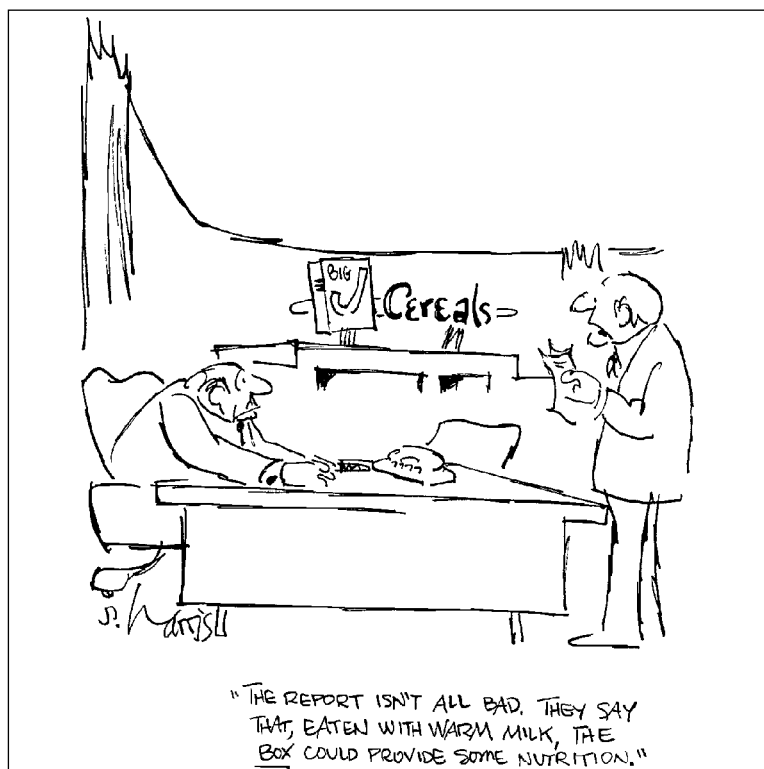
© 1993 by Sidney Harris. Reprinted with permission.



CHEM 13 NEWS, May 1979, p. 2. Reprinted with permission.



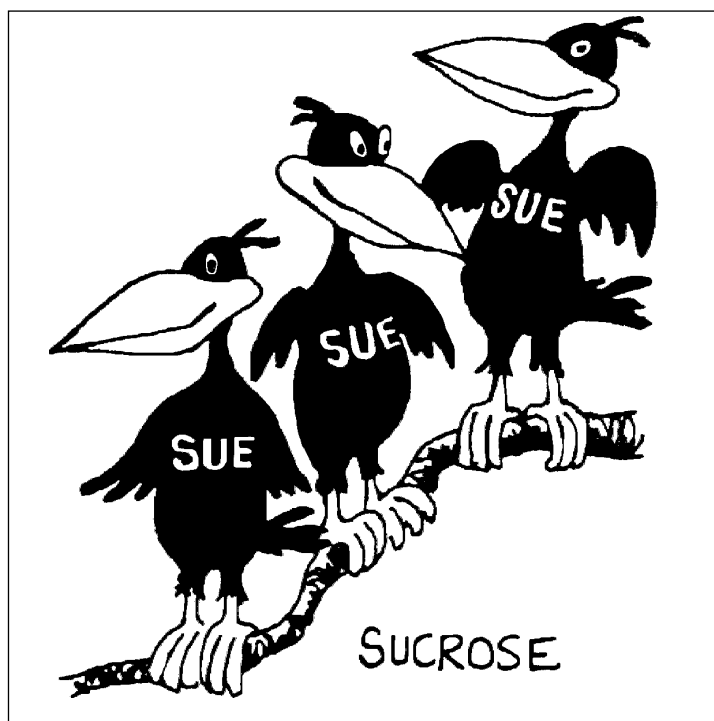
© 1993 by Sidney Harris. Reprinted with permission.



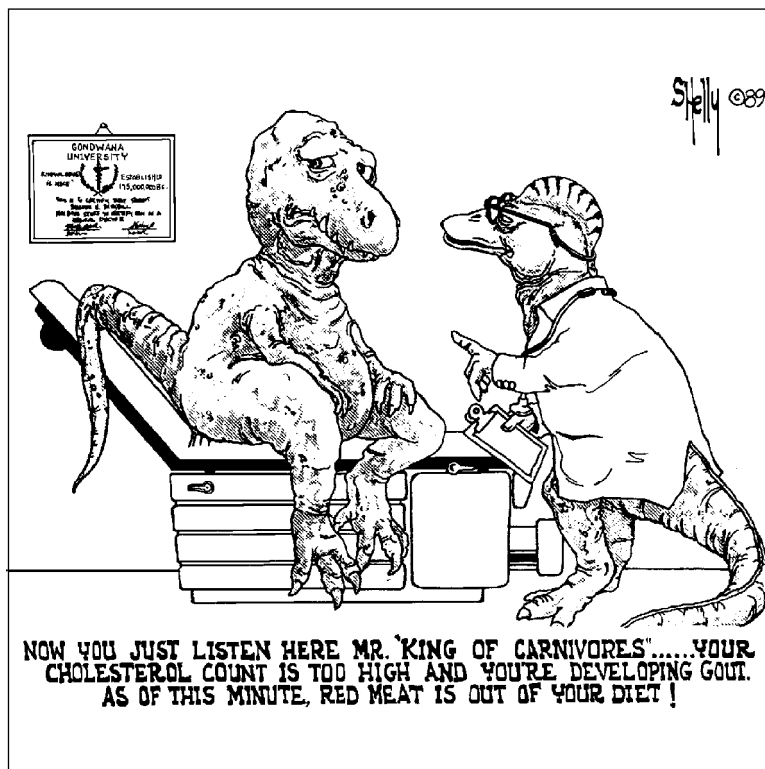
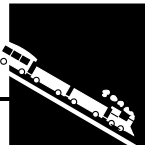
© 1993 by Sidney Harris. Reprinted with permission.



CHEM 13 NEWS, May 1979, p. 5. Reprinted with permission.



Used by permission of Veritex Publishing Co.



Cartoon by Shelly Fischman. Reprinted with permission.